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A FAST TRAIN RUN was made from Los Angeles, Cal., to Chicago, Ill., 2,265 miles, by a special train arriving in Chicago at 1:30 o'clock on March 29, over the Atchison, Topeka & Santa Fe R. R. The train making the run was a special chartered by Mr. A. P. Peacock, one of the directors of the Carnegie Steel Co., in order to enable him to attend a directors' meeting of his company in Pittsburg, and it made the run of 2,265 miles in 58 hrs. 30 mins., or at an average speed of 38.9 miles per hour. It is stated that this time beats the record from the Pacific Coast to Chicago by about eight hours. For long distances of the run the train maintained a speed of 60 miles an hour. The train was made up of the locomotive, a Pullman car, a combination car and a baggage car.

A 1,000-MILE MOTOR VEHICLE COMPETITION is to be held in England from April 23 to May 12. The course will be from London to Edinburg and return, and one day exhibits will be given at the principal cities en route. The vehicles are to be divided into seven classes, according to their selling price. A detailed program has been issued by the Automobile Club, of 4 Whitehall Court, London.

NICKEL STEEL RAILWAY RAILS have been rolled for the Pennsylvania R. R. Co., and laid on the west track of the famous Horse Shoe Curve near Altoona, Pa. A letter from Mr. Wm. H. Brown, M. Am. Soc. C. E., the Chief Engineer of the company, recently published in the "Railroad Gazette," gives the following interesting details of this installation: The order for 300 tons of 3% nickel steel rails was placed with the Carnegie Steel Co., on June 26, 1899. The steel was made by the Bessemer process and the rail was rolled to the 100-lb. Am. Soc. C. E. section. In rolling the nickel content caused "red shortness" to such an extent that the rolling resulted in only 220 tons of No. 1 and 57 tons of No. 2 rails, and 19 tons of the latter had to be thrown away because of piping. The average analysis was as follows: Carbon, 0.504%; phosphorus, 0.094%; manganese, 1%, and nickel, 3.22%. Under the straightening presses the rails showed great rigidity; twice the force ordinarily used being required to accomplish the cold straightening, and often the rail would spring back to its former position after being struck, showing no effect of the blow. In drilling the hardness was even more marked, in some cases five twist drills of ordinary tool steel being used up in drilling one hole. After experimenting with different materials for drills, it was found that the best results were obtained by using Mushet steel drills without lubrication. The rails have not been in service long enough to afford any records of their wearing qualities

DISTANT SIGNAL WIRES LAID IN PIPES are in use at a number of points on the Lake Shore & Michigan Southern R. R. The line enters the pipe as soon as convenient after leaving the wire lock at the derail and continues to as near the distant signal as practicable. The pipe is laid in a box of 1-in. boards 6 ins. wide, which is placed in a shallow trench and is laid as near as possible in a direct line to the signal. If the line is on a curve this curve is followed along a line just outside the ends of the ties. The side strips of the box are put on so as to break joints with each other and with the top piece. The pipe is ½-in. in diameter and is jointed together in lengths after being cleaned internally; it is coated on the outside with hot roofing cement. The wire is continuous in one piece through the pipe, which is filled with oil. A separate pipe is used for each wire. The ends of the pipe are formed by putting on a washer of the right size and then screwing on a long cap over a packing of wicking and tallow, which does not need to be tight enough to bind the wire at all. A drop well of U-shaped 2-in. iron pipe is inserted at the middle of each pipe line. Crude petroleum is used for filling the pipe, and refilling is required about twice a year. The cost of this pipe line is about $115 per 1,000 ft.

THE MOST SERIOUS RAILWAY ACCIDENT of the week occurred at Fort Worth, Tex., on the line of the Missouri, Kansas & Texas Ry., on March 23. A crowded passenger train ran into an open switch upon which were standing a number of logging cars. Two persons were fatally injured and a number seriously hurt.

A NEW TYPE OF LOCOMOTIVE for freight service is being introduced on the Chicago, Burlington & Quincy R. R., and is a development of the Columbia type of passenger engine first used on this road. These new engines which are designated as the Prairie type, have six driving wheels, a leading pony truck, and a pair of trailing wheels whose axle has a lateral play of 1 in. The engines have piston valves, straight-top boilers, modified Belpaire fireboxes, and the middle pair of driving wheels have blind tires. The engines were designed by Mr. F. A. Delano, Superintendent of Motive Power, and Mr. F. H. Clark, Mechanical Engineer, and were built at the company's shops. The leading dimensions are as follows:

Driving wheels	5 ft. 4 ins.
Truck wheels	3 " 1 "
Trailing wheels	3 " 1 "
Wheelbase, driving	11 " 4 "
Wheelbase, engine	26 " 3 "
Weight on driving wheels	96,000 lbs.
" on truck	20,000 "
" total	140,000 "
Cylinders	19 x 24 ins.
Piston valve, diam....10 ins.; max. travel	6 "
Boiler, diameter	4 ft. 8 "
Boiler pressure	180 lbs.
Fireboxes	7 x 6 ft.
Tubes.....194; diameter....2¼ ins.; length	16 ft. 1 in.
Heating surface, tubes	1,937 sq. ft.
" " firebox	139 "
" " total	2,076 "
Grate area	42 "

A LAKE AND MISSISSIPPI WATERWAY has been reported on by the U. S. Engineer Corps. The proposed route extends from the Chicago Drainage Canal at Lockport, and follows the line of the Kankakee River. The canal would be for boat traffic only, and would be 10 ft. deep and 100 ft. wide at the bottom, with locks 40 x 200 ft., and a clear headway of 22 ft. under all fixed structures. This would provide for the largest barge traffic likely to follow this route, and from the lower end of the canal the Illinois River would give an 8 ft. channel. The cost of the work is estimated at $10,400,000.

THE CHICAGO DRAINAGE CANAL may have its current and that of the Chicago River regulated by controlling works at the upper end, near Kedzie Ave. The main controlling works are at Lockport, and the distance is so great that it takes 14 hours for these works to produce any effect in the river. In view of the difficulties of navigating the river in the face of a current, these head controlling works are proposed, by which the current could be checked in an hour. The plan proposed is to put in a lock 100 ft. wide near Kedzie Ave., and the cost of this, complete, is estimated by Mr. Randolph, Chief Engineer of the Drainage Board, at $1,500,000.

THE WORK OF THE 10-CU. YD. CLAM SHELL dredge built for excavating the foundation trench for the Buffalo Breakwater, at a depth of from 60 ft. to 70 ft. below water, is briefly recorded in the Report of the Chief of Engineers U. S. Army for 1899. The material excavated was a pure soft clay. From April to October, 1898, inclusive, the dredge worked 971 hrs. and was delayed 1,254 hrs. by various causes. The number of cubic yards dredged per hour worked was for each month as follows:

April	106.5	August	236.7
May	136.4	September	237.4
June	185.4	October	236.4
July	206.8		

Of the 1,254 hours of delays, 83⅓ were charged to the cables, 157½ to general repairs, 124 to anchors and placing dredge, 37 to sheaves, 54⅛ to frictions and engines, 74½ to clam shell bucket, and the remainder to heavy seas and causes outside of the dredge. The dredging was all done at a depth of from 60 to 70 ft. below water. This dredge was fully described in Engineering News of Feb. 2, 1899.

THE NAVAL PROGRAM laid out by the House Committee on Naval Affairs appropriates $18,000,000 more than was ever before devoted to the navy in one year. The total includes $2,000,000 for a new Naval Academy, $12,000,000 to continue construction on vessels already authorized, and the constructing of new dry-docks at Brooklyn and Norfolk. With these sums eliminated $22,620,000 is set apart for new warships. These include two 14,000-ton battleships at $3,000,000 each, exclusive of armor and armament; three 23-knot armored cruisers of 8,000 tons each, to cost $4,000,000 each, and three 22-knot unarmored cruisers of 6,000 tons, to cost $1,140,000 each. These would give us in time a fleet of 17 battleships and eight armored cruisers. The plans have been completed for the three armored cruisers authorized last year—the "California," "Nebraska" and "West Virginia." According to the plans of the Naval Construction Boards, these ships would have 13,000 tons displacement, 23 knots speed, carry 2,000 tons of coal, and have a steaming radius of 7,000 miles. They will have twin screws driven by engines of 22,000 HP., with standard naval water-tube boilers. The water-line armor belt will be 6 ins. of Krupp steel, tapering to 3½ ins. at bow and stern; above this belt is a 5-in. casement, extending half the length of the ship and covering ten 6-in. guns. The 8-in. gun turrets will be 6 ins. thick, the conning tower 9 ins., and the signal tower 5 ins. thick. Including the 4-in. protective deck the armor will weigh 1,427 tons. The armament will include 66 guns, distributed as follows: Main battery, four 8-in. guns of 45 calibers length in elliptical turrets; 14 6-in. rapid-fire rifles of 50 calibers length. Secondary battery, all rapid-fire, 18 14 pdrs., 12 3 pdrs.; 4 1 pdr. automatic; 4 1 pdr. single fire; 2 3-in. field guns and 2 Gattlings. The ammunition hoists will be arranged to deliver at a rate of from one shot in 50 seconds for the 8-in. guns, to ten rounds per minute for the 1 pdrs. The total ammunition carried will amount to 410 tons.

THE SUPERIMPOSED TURRETS of the battleship "Kearsarge" are reported as working well in her recent trial at sea. Capt. Wm. M. Folger reports that there was no interference or inconvenience experienced by the occupants of either turret when the 8-in. or 12-in. guns in the other were discharged; the mechanical and structural conditions are satisfactorily met; there is a great saving in weight, and the 8-in. ammunition hoist is better protected. There is also no interference with gun fire, and a heavy concentration of fire is obtained. But, says Capt. Folger, a battle trial can alone decide whether it is well to put four guns in one structure of different caliber, different speed of working, range and energy, and all subject to be put out of action by any disarrangement of the turret machinery. In the final trial of this ship, all the guns of both superimposed turrets, the 5-in. rifles and 6-pdrs. in broadside, are to be fired simultaneously. No such test has ever been given to any battleship afloat.

A NAVAL BASE AND COALING STATION at Guam has been decided upon by the Navy Department. The complete survey of the harbor and part of the island has been received, and it is proposed to build a breakwater at Port San Louis d'Apra, to erect repair shops and to build a coal-shed of 20,000 tons capacity, fitted with automatic loading machinery, etc. It has been found that a whole day can be saved on the voyage to Manila by running fast and recoaling at Guam. Guam occupies about the same relative position to the China coast that Bermuda does to the Atlantic seaboard of the United States. It is 1,506 miles from Manila, 1,823 miles from Hong Kong, 1,700 miles from Shanghai, and 1,342 miles from Yokohama.

THE CRAGIN-GRACE ISTHMIAN CANAL syndicate has been formally organized. On April 3 the Inter-Oceanic Canal Co. was incorporated in New Jersey, with a capital of $100,000,000, to construct a canal between the Atlantic and Pacific oceans through Nicaragua. The incidental powers conferred on the company under its articles of incorporation are the right to acquire concessions from any government to construct, own and operate, railways, telegraph, telephone, cable and steamship lines, to supply wafer to towns for irrigation, motive power or other purposes. It is also provided that any government while a stockholder of the company may have the privilege of naming a director or directors. It is further provided that the annual meeting of the company shall be held in Jersey City on the first Tuesday in May. The directors are empowered to fix the amount of working capital, to issue bonds and mortgages and to determine when and under what conditions the books of the company shall be opened for inspection. Five directors are provided for and those in office may at any time increase or decrease this number and may appoint an executive committee of three or more with whatever powers the board of directors may confer on it. According to the terms of the concession granted by the Nicaraguan government to Messrs. Edward Eyre and Edward F. Cragin, the company to build the canal was to be organized within six months after the termination of the old Cardenas-Menocal contract, which expired Oct. 9, 1899, and the present organization is made to meet these terms.

THE LANGEN SUSPENDED RAILWAY.

The days when inventors of freak railway systems could get the ear of capitalists seem to have passed in the United States, or at least there has been a lull in their activity since the days of Capt. Meigs, with his famous Boston Rapid Transit scheme, and of E. Moody Boynton, with his bicycle railway. On the other side of the water, however, inventors of this class still flourish apparently, and we illustrate in the accompanying cut one of the most remarkable railway systems that ever

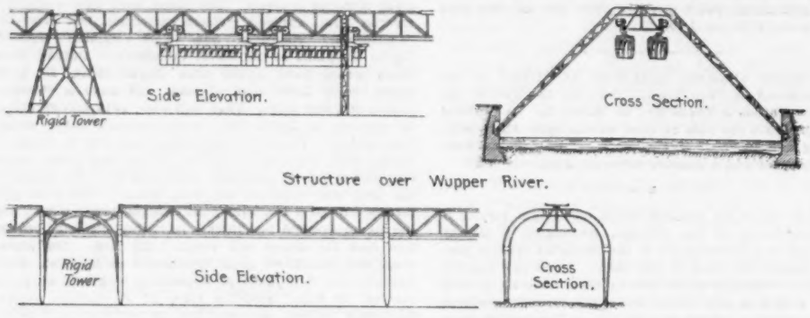


FIG. 1.—SIDE ELEVATIONS AND CROSS-SECTIONS OF LANGEN SUSPENDED RAILWAY.

reached the stage of actual construction. It is the invention of Herr Eugene Langen, of Cologne, and the line now being built extends through the towns of Barmen, Elberfeld and Vohwinkel, Germany. A section long enough to allow of tests has been completed and is illustrated in the accompanying cuts, and it is stated that the whole road, some 8¼ miles long, will probably be completed this year. Our contemporary, the "Zeitschrift des Vereines Deutscher Ingenieure," from whose pages the accompanying illustrations are reproduced, has published a description of this system taken from a pamphlet issued by the builders of the present road, the Kontinentalen Gesellschaft für elektrische Unternehmungen of Nuremberg. The following is translated from the above-named article:

The first experiments with Herr Langen's hanging railway were made with a two-rail system, and an experimental line was built at Cologne. This was an elliptical track, 328 ft. in length, with two sharp curves of 33 ft. radius. Upon this a speed of 7.5 miles per hour could be attained. A second track was then built of the same dimensions, but with only a single rail. The cars were suspended by two trucks and were free to swing sidewise. On this a speed of 15.5 miles per hour was reached; and at this speed the cars swung outwards on the curves with an inclination of 25° from the vertical. The passengers, however, had no disagreeable sensations, and the tests were considered a success. It was therefore proposed by the owners of the Langen patents to erect a suspended railway for the cities of Barmen, Elberfeld and Vohwinkel, where an ordinary elevated road was being planned by the municipalities, and the proposal was accepted. Originally it was still intended to erect a two-rail construction, but, the substantial advantages of the mono-rail system having become apparent, the latter was chosen.

The road will be 8¼ miles long, and is double-track for the entire distance. Part of the way the line runs over the bed of a small stream, the Wupper, and part of the way through the city streets. Upon the main line the sharpest curves are 295 ft. radius and upon the sidings, of 19 ft. radius. The steepest grade is 4½%. It is never necessary to slacken speed because of the grades or curves of the main line.

The supporting structure, as well as the cars and their mode of suspension, is shown in Fig. 3 and details are illustrated in Figs. 1 and 2. Over the Wupper the roadway is carried by inclined posts, as shown in Fig. 3, and in the city streets by curved posts. The posts are left free to move in the direction of the road, which allows for expansion and contraction of the supported spans due to temperature changes. In order to render the structure stable, rigid towers are placed at intervals of 200 or 300 yds., and the track is left free to expand in either direction from these.

The car hangs from two trucks placed 26¼ ft. apart. Each truck is provided with two wheels carrying between them an electric motor designed to deliver 36 HP. at 500 volts. The arrangement and mode of suspension of the trucks are well shown in Fig. 2. The truck-frame r surrounds the sleeper t quite closely in order that the wheels may not jump the rail, and that the car may not be precipitated to the ground as the result of the failure of some detail of the truck. The current is taken from a contact-rail by a slip-shoe. The speed is controlled, as in street-railway practice, by series-parallel arrangements of the motors and resistance. Braking is provided for by Westinghouse air-brakes, hand-brakes and devices to short-circuit or reverse the motors. A maximum speed of 25 miles per hour is expected. The cars will carry 50 persons and it is expected that trains of one or two cars will be operated, although the stations will admit four-car trains. The cars may be reached by elevated stations, which, however, are much lower than is usually necessary with elevated roads.

The span of the supports, partly because of the unsatisfactory nature of the foundations along the Wupper and partly to avoid obstructing the street traffic, is made very great, in some places nearly 98 ft. However, the total weight of supports and track on the line over the Wupper is only 766 lbs. per ft., and in the streets only 715 lbs. per ft. The total cost of the structure, inclusive of foundations and stations, is from $172,000 to $192,000 per mile.

We fail to find in our contemporary's description any statement of advantages, real or imaginary, to be gained by this peculiar form of construction over the ordinary railway systems in common use. We should imagine that the swinging of the car in pendulum fashion, as it rolls along, might be so considerable as to make riding in it very uncomfortable for persons with a tendency to sea-sickness. At high speeds this swinging might even become so great as to cause derailment, and it would at least complicate the problems of rail wear and rail support in a most troublesome manner. Other objections to the system are so obvious that we need not point them out; and we give space for its illustration here only as a curious monstrosity in engineering, which is not likely to be anywhere repeated.

Since the above was in type we have received from Mr. O. Petri, General Manager of the company above named, a large pamphlet fully describing the system, which he informs us has been patented in all civilized countries, the patents being controlled by his company. The advantages here claimed for the system are, that sharp curves can be traversed at high speed and with perfect safety, and that an elevated railway on this system offers the minimum of obstruction to light and air. An exhibition line on this system will be shown at the Paris Exposition.

OSHKOSH & NEENAH INTERURBAN ELECTRIC RY.

(With full-page plate.)

The interurban electric railway between Oshkosh and Neenah, Wis., a distance of 16 miles, was put in regular operation in the early part of

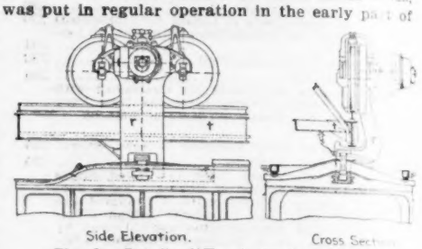


Fig. 2.—Detail of Truck for Langen Ry.

September, 1899, and connects at Neenah with the Fox River Valley Electric Ry., an interurban railway, which runs north to Appleton, 8 miles. The completion of this new line forms an important link in the proposed electric railway system from Chicago through Milwaukee to Green Bay, Wis., a distance of 198 miles, of which lines aggregating 106 miles are now in operation. The Chicago & Milwaukee Electric Ry. was described in our issue of Aug. 25, 1898.

Oshkosh is the county seat of Winnebago County and is located on Lake Winnebago at the mouth of the lower Fox River, 81 miles north of Milwaukee. It has a population of 32,000, supported by numerous manufactories. Neenah and Menasha form practically one city under two governments, with an aggregate population of 15,000. They are located in Winnebago County, and on Lake Winnebago at the point where the Fox River flowing northward from the lake furnishes water power for paper mills and other manufactures. The territory between Oshkosh and Neenah is thickly settled and forms one of the best farming districts in the state. Fig. 1 is a map of the line. The city of Oshkosh has a local system of electric railways.

FIG. 3.—VIEW OF THE LANGEN MONO-RAIL SUSPENDED RAILWAY OVER THE WUPPER RIVER, GERMANY.

17 miles in length, operating 14 cars. This was built in 1897, and the interurban line is an extension of this system, all being owned and operated by the Citizen's Traction Co., of Oshkosh, of which Mr. H. E. Downs is Vice-President and General Manager.

The interurban line has a single track, with sidings, and is located on the outer 18 ft. of the 66 ft. road reservation along the section line, so that

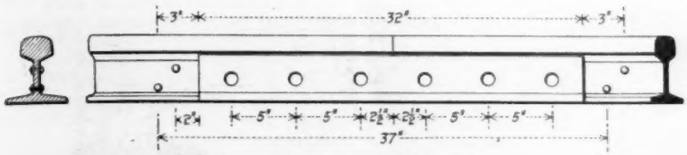


FIG. 3.—RAIL JOINT AND BONDS.

the traveled highway is not interfered with by the line, and teaming on the highway does not interrupt the cars. Fig. 2 is a view of the line, showing its relation to the highway, from which it is separated by a strip of rough ground. The line is a tangent for the first eight miles north of the city limits, after which there are long tangents with but few curves. The grades throughout are light and few, 3½% being the maximum. The rails weigh 60 lbs. per yd., and are of the Am. Soc. C. E. section, in 30-ft. lengths, spliced with six-bolt angle-bar joints with nut locks, as shown in Fig. 3. The ties are of cedar, 6×8 ins., 7 ft. long, laid 24 ins. c. to c. The rails are secured by spikes 9-16×5½ ins. The track is bonded with the Falk patent copper rail bonds, "0000" size. Two bonds per joint are used in the first four miles, two bonds per joint on one rail and one bond per joint on the other rail for the second four miles, and one bond per joint for the remainder of the line. There are four sidings outside the city limits, which are built with split switches and spring rail frogs, with long leads. There is also one siding just within the city limits, besides the ordinary sidings used for city traffic, which are built with tongue switches. The new line crosses the Wisconsin Central R. R. and the Chicago & Northwestern Ry. in Neenah, making six crossings. These crossings are built of the same section of rail that is used by the steam roads crossed, and are laid on oak timbers 10×12 ins., with gravel ballast. The three crossings of the C. & N. W. Ry. have the third rail planed down ¼-in., as shown in Fig. 4, in accordance with the requirements of Mr. E. C. Carter, Chief Engineer of the C. & N. W. Ry. This planing down is to avoid the shock caused by grooved wheels, and while from the electric railway standpoint it would probably be objectionable for single truck cars, it is not felt with the double trucks used. It gives the crossing a longer life by freeing it from the wheel blows of false-flanged wheels on locomotives and cars.

A steam dummy engine with dump and flat cars was used in the construction of the line, which plant was especially valuable in the handling of gravel, and also in the stringing of the trolley wire. The track is ballasted throughout with gravel to an average depth of 22 ins. Fig. 5 shows a train of dump cars, and Fig. 6 shows the engine and the car used in erecting the trolley wires.

The overhead construction is put up with one line of poles with flexible suspension arms. These poles are of cedar, and on straight track are 30 ft. long, set 6 ft. in the ground and having 7-in. tops. On curves, 35 ft. poles with 9-in. tops are used, set 7 ft. in the ground. There are two "Fig. 8" trolley wires, size "000." These act as direct current feeders and avoid the use of overhead switches at turnouts, for when a switch is reached, one wire continues along the straight track and the other is pulled over the siding. This construction permits a good speed through sidings and eliminates a fruitful source of trolley jumping. The alternating current is carried by three No. 6 copper wires, which are located on a cross-arm placed just above the trolley wire arm. For these wires, large glass insulators are used specially made for high voltage lines. A two-pin cross-arm located 2 ft. above the feed wire cross-arm carries the telephone wires, which extend from the main station to the end of the line, a distance of about 16¾ miles. Telephone boxes are located at all switches, and also in the general office, sub-station and main station. Garton lighting arresters are used at ¾-mile intervals. Special attention was paid to guying the poles at curves, which was done by means of stubs with 5-16-in. steel stranded cable.

The main station was originally built for the Oshkosh city system and is located on Lake Winnebago, about ¾-mile southeast of the point from which the interurban cars start. It was orignally equipped with two Hamilton-Corliss engines, with cylinders 20×42 ins., belted direct to two 225-K-W. General Electric direct-current generators. Steam was furnished by two Babcock & Wilcox water tube boilers, 36×16 ft. with 96 4-in. tubes. For the additional service of interurban cars, increased power was necessary and the following changes were made in the station. An additional boiler similar to the existing ones was installed, and also a Worthington condenser of sufficient size to condense the steam from the two engines. One of the direct-current generators was moved to a new foundation so that it was run tandem with the other generator from the same engine, one belt running on top of the other. The fly-wheel of the second engine was lagged with wood, so that its diameter was increased from 16 ft. to 17 ft. and its width from 26 ins. to 38 ins. A 6,600-volt, three-phase, revolving-field, alternating-current generator of 300 K-W. capacity was belted direct to this engine and excited by a four-pole 13½-K-W., 125-volt exciter. Three 50-K-W. oil cooled transformers, 6,600-volt alternating to 375 volt and one T. C. four-pole, 150 K-W. rotary converter, were put in place, together with new switchboards and other appliances and instruments.

A sub-station and car house was built 11½ miles from the main station. This contains one 150-K-W. converter, three transformers and switchboard with instruments. This building also contains living rooms for the station man and his family. Circuit breakers and knife switches are installed at the city limits of Oshkosh, so that the interurban line is generally insulated from the city section, but when desired the switches can be closed and the entire system operated as one circuit. A 300,000 circular mil. cable carries the power from the rotary in the main station to the double trolley wires at the south end of the interurban line, and the rotary in the sub-station feeds directly into the two trolley wires passing the station. It is found by this arrangement that there is no difficulty in maintaining the voltage over the entire line.

The arrangement of alternating and direct current machinery in the station permits of great flexibility by giving four different systems of furnishing power. (1) The engine driving the alternator is allowed to remain idle and the alternating machinery entirely cut out. The entire system (both city and interurban) is then operated by the two direct-current generators driven by one engine. The three-phase wires and the 300,000 circular mil. feeder are used as direct current feeders for the interurban system. Two cars have been operated on the interurban line and run on schedule time by this system, but the voltage is necessarily uneconomically low on the north end. (2) The engine driving the alternator and the alternator itself both remain idle. The rotary converter is then operated from the two direct-current generators as a motor generator, generating current at 375 volts, which is raised by the transformers to 6,600 volts alternating and sent out over the three-phase wires to the sub-station, where it is transformed and converted to 550 volts direct current, with only the ordinary line loss. (3) The direct-current generators are shut down and the city and interurban lines are both operated by the rotaries. (4) Both engines and all generators are run, using direct current for the city and alternating current for the interurban, or both may be cut in together. System No. 1 is not economical on account of the loss of power on interurban service through low voltage, and system No. 3 throws too much load on the rotary in the main station for regular operation. These systems are, therefore, used only for emergency service in case of repairs to the other machinery. System No. 2 is generally used for moderate loads, and as it requires the running of but one engine it gives the greatest economy, while maintaining a satisfactory voltage throughout. System No. 4, by running all of the engines and generators, gives the full power of the station, which is sufficient to meet the heaviest requirements of service.

The interurban line is equipped with six double-truck cars built by the St. Louis Car Co., of St. Louis, Mo. The dimensions of these cars are as follows:

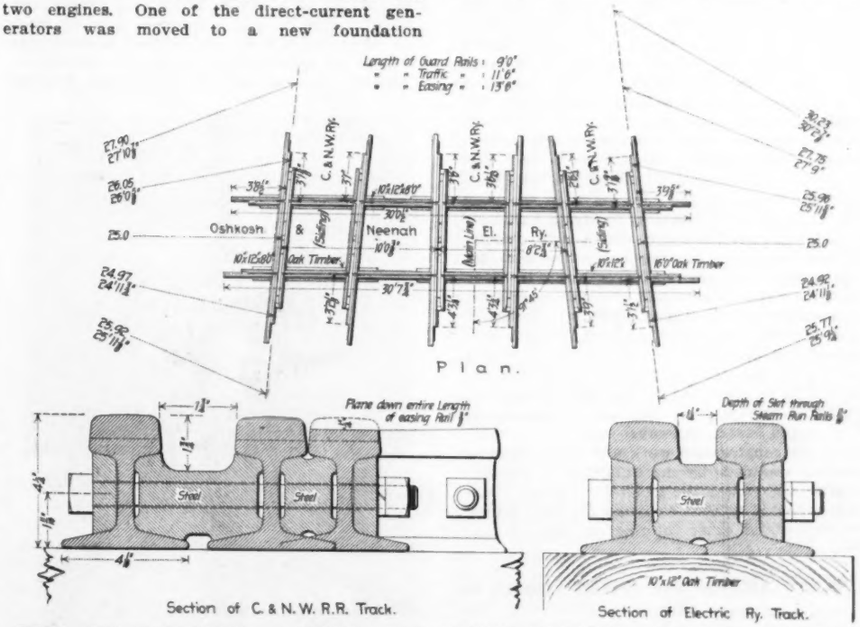

Length of Guard Rails: 9'0"
" " Traffic " : 11'6"
" " Crossing " : 13'0"
C. & N. W. Ry.
Oshkosh & Neenah El. Ry.
Oak Timber
Plan.
Plane down entire Length of casing Rail ¼"
Depth of Slot through Steam Run Rails ⅝"
Steel
Section of C. & N. W. R.R. Track.
Section of Electric Ry. Track.

FIG. 4.—TRACK CROSSING OF OSHKOSH & NEENAH ELECTRIC RY. AND CHICAGO & NORTHWESTERN RY.

Length	out-to-out	over	body	34 ft.
"	"	"	vestibule	43 ft. 6 ins.
"	"	"	bumpers	46 ft.
Width	"	"	panels	8 ft. 6 ins.
"	"	"	guard rails	9 ft.
Height, rail to top of trolley board				12 ft. 5 ins.
Height of body, sill to trolley board				9 " 4 "

The cars have center aisles with cross seats. Four of the cars have smoking compartments with cross seats in one end, and the other two have express compartments with smoker seats. They are equipped with the St. Louis Car Co.'s trucks, with four General Electric "1000" motors per car (one on each axle), Christensen air brakes, Baker hot water heaters and arc headlights. When running on a level, with a line voltage of 500 volts, they make a speed of 37 miles per hour with full current. The schedule time, however, owing to slow time in the city ends, and the desire to make the run on even schedule, is 50 minutes. During the winter, two cars are operated regularly, giving a service each way every hour and the cars leave on the even hour. It is intended, however, to give a half-hour service during the summer, which will require four cars regularly, leaving two extra cars for Sundays and other days of heavy business, when trailers may also be attached. The passenger traffic has so far been very satisfactory, and considerably in excess of what was expected from the first operation. A large part of this business is said to be due to the fact that the management adheres rigidly to the schedule, the cars leaving and arriving as promptly on time as in the case of well-managed steam railways.

All of the construction work and installation of machinery was done by the Falk Co., of Milwaukee, Wis., which was the general contractor, and we are indebted to that company for blue prints, photographs and other information used in this article.

THE MILLER CABLEWAY FOR COALING VESSELS AT SEA.

Nearly every newspaper reader is more or less familiar with the difficulties which the American fleet encountered in securing coal during its search for the Spanish squadron under Admiral Cervera, and while it was subsequently blockading that squadron in the harbor of Santiago. This experience was, as many of our readers also know, simply a repetition of the experience met with by every modern navy in the time of war, and one which has led the great naval powers of the world to expend millions of dollars in establishing and fortifying coaling stations at strategic points in their own and foreign waters. Even the nations which are best provided with such permanent coaling stations, however, are compelled to resort to some extent to the use of colliers from which, in the enemy's waters at least, they are compelled to transfer the coal to their war vessels in the open sea. In port, or, with a very quiet sea, this is not a very difficult operation with modern devices, although it always necessitates the stopping of the fleet to accomplish it, but in a moderate sea, and of course much more so in a heavy one, it has been found practically impossible to keep a collier and a war vessel close enough alongside each other to permit coaling without extreme danger to the weaker ship. During the blockade of Santiago the sides of American colliers were in several instances stove in while war ships were attempting to coal alongside in a heavy sea.

The preceding statements could easily be enlarged upon by quoting at length actual experiences in our own and in foreign navies, but they are sufficient by themselves, we think, to show the great utility of a device which will enable war vessels to coal at sea from colliers in at least moderately heavy seas, and without serious hindrance to the operations of the fleet. It would certainly be a reflection upon the intelligence of naval engineers to say that this fact had never been perceived by them, and as a matter of fact we find upon investigation that devices for coaling vessels at sea have received study from naval men for at least a score of years. It is out of the question to present here even a partial record of these studies, but it may be stated that the majority of the devices which have proved of any merit have involved two common ideas: (1) the towing of the warship by the collier or the collier by the warship, and, (2) a cableway stretched from one vessel to the other on which the bags of coal were transported in the familiar manner of such machines. The chief difficulty with all of these cableway devices has been to compensate properly for the plunging of the vessels toward and away from each other in a heavy sea, and this is the difficulty from which most of them have failed. The device for coaling at sea which we illustrate in the accompanying cuts involves, like former devices, both the towing and cableway ideas, but is particularly notable for the success with which it has apparently overcome the difficulty from which the others have usually failed.

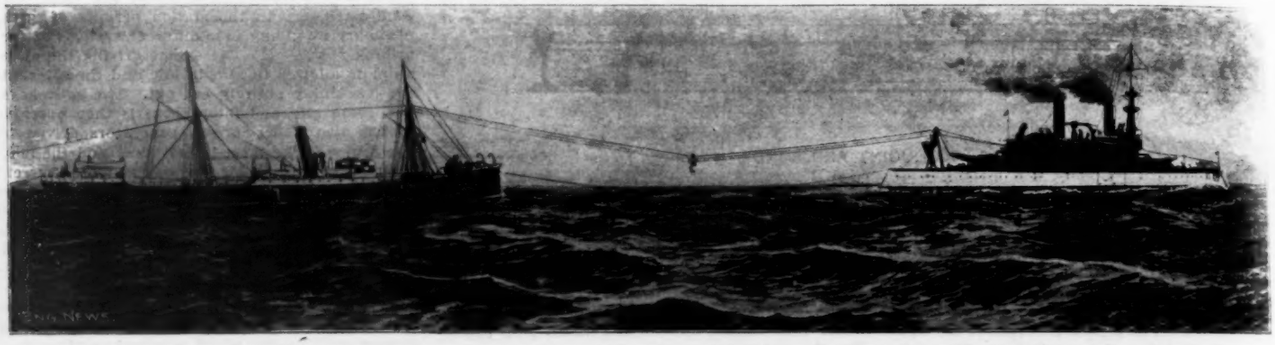


FIG. 1.—VIEW OF MILLER CONVEYOR FOR COALING VESSELS AT SEA, INSTALLED FOR OPERATION.
Lidgerwood Mfg. Co., New York, Builders.
Spencer Miller, M. Am. Soc. C. E., Inventor.

Fig. 5.—View of Collier Masthead, Showing Coal Bags in Position for Loading.

This device owes its suggestion to Naval Constructor J. J. Woodward, who, just before the breaking out of the Spanish-American war, sent a plan in outline for coaling a warship from a collier in tow by means of a cableway to the Lidgerwood Mfg. Co., of New York, with the request that they should submit plans and proposals. From this point the work was taken up by Mr. Spencer Miller, M. Am. Soc. C. E., Engineer of the Lidgerwood Mfg. Co. As the result of his work the Navy Department made a contract with the Lidgerwood Mfg. Co., to equip the collier "Marcellus" with the device. This contract specified that the apparatus should safely transfer coal from the collier in tow of a battleship to the battleship at the rate of not less than 15 tons per hour, with a distance of not less than 300 ft. between the two vessels. The ability of the apparatus to satisfy these conditions was to be determined by a sea trial. The war ended shortly after this contract was made, and all need of haste being thus done away with, the installation was not completed until late in 1899, the final tests, which proved satisfactory, being completed in December of that year. As finally worked out and tested the apparatus is shown by Figs. 1 to 8.

Fig. 1 is an engraving from a drawing showing a battleship towing a collier with the cableway coaling device in operation between them. Briefly described, the apparatus is as follows: A portable shear leg is erected on the after deck of the battleship. This shear leg is guyed to the battleship and is provided with the necessary attachments to form one of the towers or supports for the cableway. The other tower is formed by the foremast of the collier. Just abaft the collier's foremast and on deck is located a special form of hoisting engine having two drums. From one drum of this engine a wire rope is led to and over a pulley at the masthead and thence to a sheave at the head of the shear legs on the battleship and thence back to the collier's masthead and down to the other drum of the engine. These two lines of rope constitute the conveying rope for the bags of coal, as will be explained a little further on. In addition to them there is a third line of rope known as the sea anchor line, located above them. This sea anchor line is attached by a "knock-off hook" to the inboard superstructure of the battleship, and passes over a saddle on the head of the shear legs, thence through the carriage and over a sheave at the collier's masthead to a sea anchor, which is towed astern of the collier. A trip rope returns from the sea anchor to the stern of the collier. These ropes, together with the tow line, compose the cable system uniting the two vessels.

Besides the engine for operating the conveyor ropes there is another hoisting engine on the collier whose duty it is to operate a special form of elevator, which travels back and forth between the masthead and deck of the collier. This elevator on its up trip carries two bags of coal, each weighing 420 lbs., and holds them at the masthead until they are hooked onto the carriage traveling on the conveyor ropes and sea anchor line.

Turning now to the operation of the conveyor ropes, the first thing to note is that the winding engine moves in the same direction all the time and tends to wind in both parts of the conveying rope. One drum actually hauls in its part of the rope and the other tends to do so, but does not owing to the slipping of the drum; that is, it actually pays the rope out under tension. Referring now to the line drawing Fig. 2, which shows the construction at the collier's masthead, there will be seen the rope coming from the tension drum and above it the return rope from the warship to the friction drum. Above these is the third rope of the sea anchor line. The carriage, as is clearly shown by the drawing, is supported by grooved wheels on the lowermost rope and the sea anchor line, and clasps the middle rope by means of a spring grip. The operation is as follows:

The carriage, having taken its load at the masthead, the engine operator hauls in on the lower conveyor rope, and the upper conveyor rope is thereby paid out under tension by the slipping of the friction drum, thus moving the carriage with it toward the warship. The lower rope is drawn in at a speed of 1,000 to 1,500 ft. per minute, and if the points of support, which are the collier's masthead and the battleship's shear legs, do not vary in their distance apart, the upper rope will be paid out under a tension of 3,000 lbs., at the same rate of speed. Should, however, the distance between the points of support be increased during the transit of the load by the plunging apart of the vessels, the extra rope called for will be given by the slipping of the upper rope from the friction drum at increased speed. On the contrary, should the plunging toward each other of the vessels shorten the distance the upper rope will cease to slip from the drum until the lower rope has hauled in the slack. It will be seen that this arrangement compensates perfectly for the relative motion of the vessels, providing the hauling speed of the lower conveyor rope is twice that at which the points of support can approach or recede from each other.

To return the carriage to the collier after it has dropped its load at the warship the drum carrying the lower rope is thrown out of friction to a reduced friction and the upper rope is hauled in by the other drum. At this point the utility of the sea anchor line comes in by supporting the weight of the empty carriage on its return trip. Were it not for this support the carriage empty might turn on the ropes twisting them so as to lose time in untwisting them. The sea anchor line permits the return of carriage with line slacked. At times it is quite likely that the sea anchor line also helps to support the loaded carriage on its forward trip, but the conveyor lines will sustain the load without this aid and are supposed to do so.

The operation of the carriage is simple. As already stated, the bags of coal, two at a time, are hoisted to the collier's masthead by means of a special elevator, where they are held by a single bail. The carriage coming in to the masthead locks itself under this bail and moves off with the load. When it reaches the pulley at the shear head on the warship it collides with it, at reduced speed, of course, in such a manner as to unlock the load, which falls into a canvas chute leading to the deck. The line drawing, Fig. 3, shows this operation and the general nature of the shear legs, pulley and chute construction on the warship. Fig. 4 shows the details of the shear-head construction.

The general operation of the conveyor is, we think, made quite plain by what has been said, but some of the details require a little more explanation. Referring to Fig. 2, attention may be directed to the arrangement by which the carriage automatically picks up the loaded bags. The two bags of coal hang side by side in the elevator by which they are supported by means of a bail held by a form of latch hook. The carrying arm of the carriage coming in to the masthead passes through this bail and unlocks it from the latch hook. To ensure that the carrying arm of the carriage shall always pass under the bail the interior side surfaces of the elevator converge so that they act like the sides of a ferry-boat slip to direct the motion of the carrying arm. The view, Fig. 5, shows this arrangement quite clearly, and also shows the general arrangement of the crosstrees with the man in attendance. Usually in regular operation there are two men on duty at the collier's masthead. It will be noticed that the elevator car carries a hook on each side. This is for the purpose of returning the empty bags to the deck which are returned from the warship on the side hooks of the carriage.

Fig. 6 is a view of the carriage, which shows its construction somewhat more clearly than does the line drawing. Fig. 7 is a view from the bow of the collier looking toward the stern of the warship and showing the carriage with its load in transit. Fig. 8 is a view of a portion of the deck of the collier showing the double drum engine for operating the conveyor carriage and the hoisting engine employed to run the elevator. The photographs, from which Figs. 5 to 8 are reproduced, were taken on board the collier "Marcellus," of the U. S. Navy, during the official trials, and show the apparatus under actual working conditions. The only essential portion of the apparatus whose construction is not made clear by these illustrations and the description which precedes, is the special friction drum arrangement of the conveyor engine. This the inventor is not yet ready to make public.

Fig. 7.—Stern View of "Massachusetts," Showing Coal Bags in Transit from Collier.

The usual test of a device of that kind is, of course, its operation under actual service conditions, and to determine this the sea trials were made. These were of various kinds, but the concluding rough weather trial was the one of particular interest. In this trial 1½ hours were consumed in securing the tow line and setting up the apparatus. The test was made with the battleship "Massachusetts," towing the collier "Marcellus." The vessels steered at first head on to the sea, which was so heavy that the forecastle of the "Massachusetts" was washed at every plunge. The course was then changed quartering on the sea, and finally the vessels steered in the trough of the sea. The speed was maintained at about five knots. The trial lasted 80 mins., during which time the carriage made 80 trips loaded. By weight a little over 20 tons of coal per hour were put on board the "Massachusetts," which burned about 3½ tons per hour during the trial, making a net gain of 16½ tons of coal per hour. The distance maintained between the two vessels was about 400 ft. As the result of this successful trial the government has purchased the plant installed for the trials. The U. S. patents on the Miller conveyor for coaling at sea are controlled in the United States by the Lidgerwood Mfg. Co., of New York city, Mr. Spencer Miller, M. Am. Soc. C. E., Engineer. We are indebted to Mr. Miller for the information from which this description has been prepared.

TWO EXAMPLES OF WATERPROOFING IN ENGINEERING STRUCTURES.

In the December number of the "Proceedings of the American Society of Civil Engineers" was printed an exhaustive paper by Mr. Geo. B. Francis on the South Terminal Station at Boston. In considering the design of this station a suburban loop track service upon a floor beneath the main floor was finally decided upon; but this brought the lower tracks 7 ft. below the level of very high tides. As the station is close to the water front, this immediately introduced the study of waterproofing this great area of about ten acres to shut out the water. Due consideration showed it to be feasible to do this without prohibitory cost. The following description of the method of waterproofing is taken verbatim from Mr. Francis' paper:

The permanent waterproofing sheet, which underlies the whole lower floor, consists of ten layers of tarred paper, swabbed together with hot coal-tar pitch. The layers are carefully lapped, and all built in place. This continuous sheet of waterproofing, amounting to 56,000 sq. yds., or upwards of 10 acres, is laid, where horizontal, upon a concrete base, troweled to a smooth surface. In some of the softer places boards were laid down under the concrete base, but usually this base, 6 ins. thick, rests upon the ground. Where the waterproofing is on the vertical walls, it is backed up with 8 ins. of brickwork. In all cases the horizontal sheet lies between the pile heads and the granite masonry above.

Upon the waterproofing sheet, where it is not weighted down with walls, there is placed a loading of a cheap grade of Portland-cement concrete, sufficient to resist the upward pressure of the water, which is, on the horizontal layers, about 500 lbs. per square foot, this pressure being dependent, of course, on the elevation of the sheet, with reference to the ground-water level. In some places the weight of the walls is far in excess of the water pressure; in others, where possible, the pressure is resisted by inverted concrete arches.

A drain-pipe channel underlies each loop track for its entire length, and these discharge into the sump well near the power-house, where both rain water and any leakage through the waterproofing finds its way, either through the automatic tide gates at low tide, or is pumped at other stages of the tide into the Fort Point Channel. The tarred paper is introduced into the waterproofing sheet to give it a fiber, and the pitch to make it watertight. It was not desirable to have the sheets of paper of great thickness, as that would permit the paper to split in its own thickness, but rather a thin paper, which would saturate to a greater extent, and to make up for thickness by a greater number of sheets, the total number being a matter of judgment. The coal-tar pitch should spread under pressure, and when warmed in the hand should spin out as fine as a hair. This combination of pitch and paper was selected in preference to a layer of asphalt, as it could be bent, twisted, knuckled, abused and handled more readily than the asphalt, which, if disturbed very much, it was thought, would crack clear through. It is not believed that the pitch will volatilize in its secure position away from air. Up to the present time no leakage in this great area has been discovered.

The waterproofing work was carried on regardless of the temperature. An 8-in. brick wall was found to be the most suitable backing where the sheet is brought up back of the walls. Care had to be taken that the walls should not slide sideways upon the pitch before the concrete bracing in front was in place.

To determine the pressure likely to be exerted on the under side of the waterproofing sheet, the following line of reasoning was used:

	Elevation.
Mean high-water level is about	10.00
Extreme high-water level (during a severe storm in 1851) is registered as	15.74
Mean low-water level is about	0.00
Extreme low-water level is about	3.00
Ground-water level some distance back from the water front, by observation, is about	9.00

showing that high tides do not remain up long enough to penetrate any great distance through the ordinary earth filling.

As the sheet-pile cofferdam, with the top at elevation

16.00, put in to enable the work to be carried out, was to be left in the ground, it was reasoned that extreme high tides would not penetrate beyond the dam, and therefore that an assumed elevation of 12.00 would be safe for any possible condition. Had the coffer dam entirely surrounded the site, it is quite likely that water would have risen inside of the dam to the top of the sheathing, but as the dam does not extend entirely around the work there is ample opportunity for the ground-water to stand at its usual level.

Having assumed the water level at elevation 12.00, as giving the maximum hydrostatic pressure, it only remained to calculate the required loading of concrete for any given level of the waterproofing sheet. To distribute further any load from columns over the sheet as far as possible, old steel rails were introduced into the concrete whenever it was possible. In the case of the light loading under the loop tracks they were used to distribute a surplus loading on either side to the area under the tracks. They are also placed under the retaining walls so as to project as far as possible.

Discussion by Herman Conrow, Jun. Am. Soc. C. E., 40 Wall St., New York City.

In the summer of 1896 the writer had charge of the construction of a waterproof subway, beneath the four tracks of a railroad in Massachusetts. The subway was about 100 ft. long and 8 ft. in clear width, with the floor about 5 ft. below the level of the water in a nearby creek. It was necessary, therefore, to build a masonry structure which would be impervious to water under pressure. The design of the subway called for a foundation of concrete, brick side and end-walls, and a brick-arch roof with concrete backing. The waterproofing materials were refined bitumen asphalt of the best quality and heavy tarred paper. Inside, the finished subway was planned to have a mosaic floor and sides and arched ceilings of glazed bricks; but these embellishments have nothing to do with the waterproofing, and were added merely as a veneer to the main walls of the structure. The subway was built in a soil of fine sand so full of water that it was not far removed from a quicksand.

In order to simplify the description, the methods used in waterproofing the floor, side-walls and roof are separated.

1. The floor was waterproofed as follows: A foundation course of concrete, 6 ins. thick, was laid upon the sand, and the top of this was roughly leveled and smoothed by filling the depressions with mortar. After this mortar had set, heavy tarred paper was laid to break joints, and over the paper was poured a layer of molten asphalt. (The thickness of this pouring will depend upon the temperature of the asphalt. Very hot asphalt will run out to a thickness of less than ¼-in.; but it can be used so that the pourings will be nearly ¼-in. thick. The thin pourings, however, give the best results.) On this asphalt, after it had cooled, another layer of tarred paper was placed, which was followed by another coating of asphalt. This process was continued until a waterproof covering about 1 in. thick was formed. This was composed of three layers of paper and three pourings of asphalt. This floor covering could have been made entirely of asphalt, but the tarred paper greatly increased its strength.

Upon this waterproof floor 6 ins. of concrete were next laid, except where a space was left for the asphalt in the vertical walls to join directly to the asphalt floor. The purpose of this concrete was to keep the asphalt permanently cool and also to withstand the water pressure from beneath. Steel rails, 2 ft. apart, were placed in the concrete, and the ends of the rails were bedded under the inside walls, thus giving strength to the concrete, in addition to its weight, to resist the upward pressure, otherwise a heavier layer of concrete would have been necessary.

2. To waterproof the side-walls of this subway the general scheme was to build a core-wall of asphalt, 2 ins. thick, between two brick walls. The greatest care was necessary, in making the junction at the bottom, where the asphalt core-wall met the asphalt floor, to secure a water-tight joint. The inside wall surrounding the core was first built to a height of 6 ins. and the outside wall to a height of 1 ft., thus forming a narrow groove 12 ins. deep, into which molten asphalt was poured. In order to reduce the amount of asphalt, broken pieces of clean and dry brick were laid in the groove, which was then grouted full with very hot asphalt. The core-wall having thus been raised level with the brick walls about it, the brick walls were built up 12 ins. higher, and the process of asphalting repeated. In this manner the sides and ends of the subway were built to the desired height. When this had been done the walls and bottom formed a water-tight masonry box.

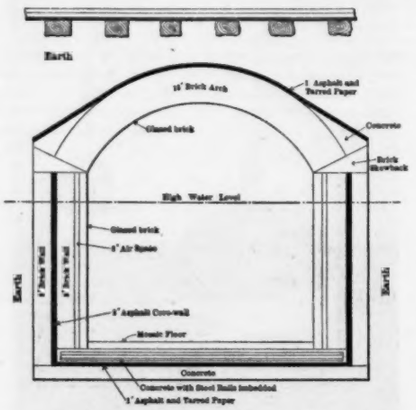
When starting the core-wall at the bottom, the asphalt was poured very slowly, for there was danger that the hot asphalt would melt that under the concrete and cause it to crack; but after the core-wall had reached a height of 1 or 2 ft., all anxiety on that score was dismissed.

To make a tight junction between one pouring of asphalt and another, the surface of the cold asphalt must be perfectly clean and dry. A film, either of dust or moisture, will prevent a water-tight junction. Sometimes, when the brick walls had been freshly built up above the core-wall, particles of mortar and drops of water collected upon the surface of the cold asphalt in the groove, and, in spite of brushing and wiping, it could not be cleaned and dried perfectly. In such cases a small quantity of kerosene was sprinkled on the surface of the asphalt in the groove and then lighted. The heat dried out the moisture and melted the surface of the asphalt, giving a perfectly new surface and making sure the unity of the work.

This use of kerosene the writer has found very valuable. Old surfaces of asphalt which had become full of indentations and which were covered with sand which had become ground in, were rendered bright and clean by burning kerosene on the surface; the foreign particles disappeared by sinking deeper into the asphalt, leaving the surface in good condition to unite with the next pouring.

3. The waterproofing of the arch covering was very simple. After the masonry had been smoothed over with cement and it had set, asphalt was poured evenly over the surface, and, after cooling, a layer of tarred paper was laid, beginning at the sides and parallel with the barrel of the arch, working upward toward the crown, each course lapping over the previous one as in a shingle roof. Four layers of asphalt and three of paper were used.

The waterproofing of the subway by these methods was entirely successful, and upon the completion of the work the pumps were stopped and the water rose to a height of 4 ft. around the walls of the subway, which remained perfectly dry inside. Numerous heavy rains caused no leakage in the arched roof.



Cross-Section of a Subway Under a Railway Track, Showing Method of Waterproofing.

This method of waterproofing the side walls was not that originally tried upon this work. At first the attempt was made to waterproof a brick wall by means of paper and asphalt. After the wall had become dry it was coated with asphalt, and then paper was put on with lap joints. Another coat of asphalt followed, then more paper, and so on. A 4-in. brick wall was built adjacent to the paper to hold it and the asphalt in place. The results were not successful, and perfect waterproofing was not secured in this way. The writer is of the opinion that tarred paper has little value as a waterproofing material for vertical walls which are to stand water under pressure, because of the impossibility of keeping the paper in its proper place. He also believes that if it is desired to build masonry absolutely water-tight, the best way to do it is by using an asphalt core-wall where the asphalt may be poured into a groove and allowed to run into every crevice which will admit water.

Both the asphalt and the tarred paper should be of the best quality. Cheap asphalt and the tar compound are not permanent substances, but will rot and become like powder under the action of water and air, thereby losing all waterproofing qualities; and the poorer kinds of tarred paper are easily torn and are of little value. It will be found very difficult to handle the asphalt in hot weather, since it becomes soft in ordinary summer temperatures. Cold asphalt is a durable and tough substance, capable of bearing considerable pressure, but if unprotected from the sun's rays, it becomes an unreliable material. It it is desired to use a large quantity of asphalt, the inconvenience of melting it quickly may become very great, especially if the asphalting outfit consists of but one or two kettles. One kettle will melt a large amount, however, if it is kept constantly full, since the molten asphalt in the kettle will quickly melt large blocks of the cold asphalt.

The accompanying section will aid in the illustration of the methods described.

FAILURES IN ASPHALT PAVEMENTS AND THEIR CAUSES.*

In asphalt work, as in hydraulic cement work, and I might say in all cases where cementing material is in use, the first cry heard, if anything goes wrong, is bad asphalt in this, bad cement in that. Such judgment is invariably passed by the large majority of people, and is a general manifestation of their ignorance or thoughtlessness, and in some cases prejudice. Take hydraulic cement, for example, as its characteristics are more widely known; how many little things are possible that will produce poor work with the best cements? Improper manipulation, admixture with inferior materials, and improper storing.

The same applies to asphalts, except to a great degree; for improper handling and admixture with poor material will produce work that will prove absolutely worthless, even though the asphalt be of the finest quality. Of course, it is much easier to spoil a poor asphalt by improper handling than a good one, but I know of cases where an inferior asphalt has made better pavements than one of superior quality, because the former was mixed and laid with greater care.

In this report I do not intend discussing the effects that different characteristics of an asphalt have on a pavement, but to take the most common practical failures as seen on the street, where an asphalt has been used whose quality has been proven superior by practical use, and point out what defects in the material or construction are responsible.

To those familiar with asphalt work the mode of disintegration can be divided into three classes: First, disintegration by cracking in long single cracks that keep extending with time; second, disintegration by rolling or shoving, the pavement becoming wavy; third, disintegration in patches, where the pavement will wear into a hole which in time will extend through to the base.

Disintegration by Cracking in Long Irregular Cracks.

It is evident to all who are familiar with asphalt pavements that such cracks are due to the contraction of the asphalt surface from cold. Some few cases have been reported where the hydraulic cement concrete under the pavement has cracked as well as the surface, but I believe such cases to be very rare. These contraction cracks usually start near the gutter and gradually extend across the street. They are also found radiating from iron sewer traps and manholes set in the pavement, which rather indicate that the coefficient of expansion of iron is greater than that of the asphalt mixture. They are often found at the joint between an old and new pavement or at the joint made between one day's work and another. The latter would not occur if the joint had been properly made. These cracks appear sooner and increase more rapidly on a street with but little or no traffic and are seldom found, unless the material has been prepared with very poor judgment, on streets with a good amount of travel. This appears on first thought paradoxical, but it is simply explained. When the pavement is subjected to a continuous traffic the asphalt surface, which is more or less plastic at all temperatures, is kept from cracking by the constant kneading, so to speak, produced by the traffic. And again, when an asphalt surface has but little or no traffic, it becomes more porous owing to the fact that expanding and contracting from heat and cold without the compression due to traffic, it becomes spongy and as a consequence materially weakened. If such cracking occurs at all on a street with a fair amount of traffic, it is evident that the paving mixture used is at fault, either in not being rich enough in bitumen or the asphalt cement used was too hard. As to the proper quantity of asphalt cement to use in a paving mixture to make it sufficiently rich, it is impossible to state any fixed quantity for all cases, as so much depends on the character of the sand. A fine sand will hold more bitumen than a coarse one, and an angular one more than a round-grained one. The softness of the asphalt cement also has an influence on the quantity that can be gotten into a mixture. The softer the cement the less of it that can be used. It is self-evident that the harder or less plastic the asphalt cement used the more liable the pavement is to crack. The general rule, therefore, to follow in this matter is to use as soft an asphalt cement as is possible without having the pavement too soft for the conditions to which it will be subjected.

Having now reviewed the causes that lead to the cracking of an asphalt surface, it will be well to look into the conditions that govern the proportioning and the selection of the materials to be used. The conditions that are hardest to meet are where the pavement has little or no traffic on a street running north and south with no shade, and in a climate that has a big range of atmospheric temperature. Such a street will have practically no traffic to prevent it from cracking, as I have explained above, and will be exposed in summer to the hottest rays of the sun, while in winter it will be subjected to the coldest winds.

*Slightly condensed from the report of Mr. A. W. Dow, Inspector of Asphalts and Cements, as given in the Annual Report of the Operations of the Engineer Department of the District of Columbia for the Year ending June 30, 1899, Under the Direction of Capt. Lansing H. Beach, Corps of Engineers, U. S. A.

The best asphalt surface mixture to meet these conditions should be made of a sharp sand, well graded from coarse to fine, with the fine predominating. It should have as much asphalt cement as the sand will hold. The asphalt cement should be as soft as it is practicable to put in the mixture without having it mark too badly in the hottest weather to which the pavement will be subjected. Let us take this extreme case and modify its different conditions. For instance, if the street is narrow and runs east and west, so that it will be shaded by the houses, or if the street is at all shaded so as to protect it more or less from the hot summer sun, the asphalt cement used can be softer, depending on the amount of shade. If the traffic is increased to what might be considered a moderate amount, the asphalt surface mixture just described will do very well from the practical side, but is richer in asphalt cement than necessary, so that it could be changed somewhat for economy. If, however, we keep increasing the traffic and the liability to crack lessens, it will become more and more necessary to alter the mixture to prevent it from rolling and crowding out of shape. The means of preventing this will be treated under the next heading of disintegration.

Some engineers have resorted to the use of expansion joints in the asphalt surface, not to prevent cracking, but, I suppose, to have the pavement crack in geometric figures. I can hardly see the wisdom of such a procedure, for if the pavement is properly constructed it will not crack in several years under the most adverse conditions, and then only at long intervals and generally in some old joint, while if the pavement is improperly made the expansion joint will be but a slight prevention, if any, for irregular cracking. The principle of expansion joints is not applicable to material with no structural strength, like asphalt mixtures. These joints are not only useless but really detrimental to a pavement, for the asphalt mixture being plastic, they are places that will be widened by the pounding of traffic. And then with asphalts that are rotted by water they offer crevices in which mud and water will collect which will slowly rot the pavement. The above objections apply equally to all cracks in pavements, so that it is better to construct the asphalt surface in the first place so that it will be less liable to crack than to put cracks in your pavement to prevent others from forming.

Disintegration from Rolling or Crowding.

This defect occurs in pavements having too soft a wearing surface, or where there is a defective bond between the base and binder or between the binder and wearing surface. It is caused by traffic pushing the surface of the pavement up into waves or crowding it toward the gutter. It is a defect that is impossible to entirely guard against on a street with an excess of very heavy traffic, and especially where the traffic is confined to a narrow section of the street. It is, however, inexcusable on streets even with moderately heavy traffic, and when occurring in such cases it will be found due to one of the above causes or to a combination of two or more of them. It is most commonly found due to the defect of making the surface of the hydraulic concrete base under the pavement too smooth, which is the case where gravel concrete is used or where a stone-and-gravel concrete is so rich that its surface is covered with mortar that was brought to the surface by ramming. Unless the binder and surface mixtures are made hard, which makes the pavement liable to crack, they will slide on such a base if there is much traffic. Pavements often roll from a defect in the binder, either because of it being too rich in asphalt cement or because it was dirty when the surface was put on, which prevented a proper union of the two. In some cases where there is a long haul from the paving yard to the street some of the asphalt cement will work down to the bottom of the cart, so that when the binder is dumped it will appear too rich in spots. All these soft, rich places should be cut out, as they are liable to be the cause of the pavement crowding over that spot. A pavement sometimes crowds from the surface mixture being too soft. There are several causes for this: A soft asphalt cement; being too rich in bitumen, and being made with a round-grained sand or a sand deficient in fine dust.

A surface mixture, to withstand heavy traffic without rolling, should be constructed with a moderately sharp sand—that is, one whose larger grains are angular yet free from jagged edges, with the grains graded from coarse to fine and having at least 25% passing an 80-mesh sieve, about 17% of which should pass a 100-mesh sieve. To this sand should be added about 5% of a fine powder of limestone, 80% at least of which should pass a 100-mesh sieve. There should be a moderate quantity of a medium-soft asphalt cement. The quantity and softness of the cement will depend on the character of the sand and the climate in which the pavement is laid.

Crowding from a soft surface mixture is much less frequent than is generally supposed, and the majority of cases where the blame is put to this cause will be found to be partly due to a defective base or binder. I have seen a surface mixture so soft on streets with quite heavy traffic that every wagon left its mark on the pavement on a hot day, yet after three years there was not the sign of a wave in the pavement. Indeed, pavements that mark much in hot weather when recently laid are much more durable than those that mark but little. This is due to the fact that all asphalt cement hardens slowly with age so that the softer the cement used the longer it will be before it becomes so hard as to be brittle.

Disintegration of Pavements in Spots.

When a pavement is laid with a surface mixture deficient in asphalt cement and the asphalt cement is so hard as to be very brittle in cold weather the pavement will be ground away by traffic, and as there are always spots weaker than others the disintegration will naturally take place more rapidly in these places. Such a pavement will disintegrate more rapidly in cold weather, and is also likely to crack badly at the same time.

There are cases of disintegration in spots occasionally met with that are caused by a rolling or softening of the asphalt surface by oils coming from the binder. This occurs most frequently in pavements laid with coal-tar binders, as there appears to be a constituent of some coal tars which is readily absorbed by the surface mixture, softening it greatly and apparently making it more susceptible to the action of water. Pavements affected this way first give signs of their disintegration by a slight depression over the affected spots. In time numbers of small cracks appear, running parallel with the street. These gradually increase in prominence, accompanied with transverse cracks, until the pavement has the appearance of alligator skin. On examining a section of the surface mixture cut from the affected spot it will be found to be quite soft near the binder if the disintegration has not proceeded for a length of time; if older, the soft zone will be nearer the surface while the bottom of the mixture will show the disintegrating effect of the water that has likely entered the pavement through the crack. The affected piece of mixture will smell strongly of coal tar, and will, in all cases, give a greenish fluorescence to a solution in carbon disulphide. The portion of the pavement thus acted on will be crowded or worn out by traffic until nothing is left of it. If the surface mixture is soft the pavement will roll at this place, the soft affected material crowding before the traffic. As the use of coal tar in binder was discontinued in this city some time ago, these cases will occur less frequently each year. Binder made with asphalt cement in some few cases affects the surface mixture in this way. It is likely caused by the presence of some free oil, which may not have been properly incorporated with the asphalt in making the binder cement.

Disintegration of pavements from the absorption of illuminating gas, escaping from leaky gas pipes or mains under the pavement: There are several streets in the city being ruined by this means, and it appears to be a common thing in all cities having gas. The pavements are affected in very much the same way as when disintegrated by coal-tar binder, except the fine cracks, running parallel with the street, make their appearance some time before the pavement begins to crowd. Pieces of the surface mixture taken up smell very strongly of illuminating gas, and in some cases the gas can be ignited by applying a match to the under surface when it has just been taken up. In nearly every case enough gas will be given off by heating a small piece of the affected pavement in a tube to have it flash by igniting.

As it has been doubted by some that this disintegration is really due to illuminating gas, I have made a most thorough investigation of the subject and believe have positively proven that gas is the cause. Samples of pavements were obtained from several affected spots, and in all cases I have been able to obtain from them a gas that exploded by passing an electric spark after mixing with air. The method employed to obtain the gas from samples of the surface mixture was by heating them under boiling water and collecting the gas given off in an inverted funnel. Those not acquainted with the properties of asphalts might suggest that heating any asphalt to this temperature might make it give off a gas. This is impossible, as an asphalt cement such as is used in paving will lose only 3 or 4% at the most on being kept at a temperature of 400° F. for 30 hours, and only an infinitesimal part of this loss in a gas at ordinary temperatures. To make a more practical demonstration of this, two samples of a pavement were taken, one from an affected spot and the other from a good portion of the pavement about 10 ft. away. These samples were treated under boiling water until they ceased to evolve gas. The affected sample gave several times more gas than did the other. On testing the gas from the good sample it was found to consist of oxygen and hydrogen, which was evidently just the air from the voids of the pavement. The gas from the affected piece gave on analysis (see column one.—Ed.):

	Per cent.	
Carbon dioxide	8.4	0.2
Oxygen	10.8	0.0
Heavy hydrocarbons	13.4	12.1
Carbon monoxide	0.7	25.5
Hydrogen	6.6	39.2
Methane	2.0	23.0
Nitrogen	58.1	0.0

Having now found that a gas is present in the pavement so affected, let us proceed to examine as to its source. It cannot be a natural gas or marsh gas, for there is no analysis of such gases on record that contains appreciable amounts of heavy hydrocarbons, while the gas from the pavement is rich in these compounds. The same would also apply to sewer air or gas. The only remaining source is illuminating gas, the analysis of which is given (see column two.—Ed.):

On comparing the composition of the gas given off from the disintegrating pavement with the illuminating gas, it is seen that they are not at all similar in composition. At first glance it would not seem possible that the former gas could originate from the latter, but when the properties of asphalt are considered it is easily explained.

Heavy hydrocarbons, to which class asphalts belong, are known to absorb other gaseous hydrocarbons; the heavier the gas the more affinity between it and the heavy hydrocarbons. Knowing this, the ingredients of the illuminating gas that asphalt would have the greatest affinity for would be the heavy hydrocarbon gases, a slight affinity for the marsh gas or methane, and no affinity for any of the other ingredients. If we examine the ingredients of the gas from the affected pavement it will be found to consist of some carbon dioxide, air that was in the voids and cracks of the pavement, and the constituents of illuminating gas with the heavy hydrocarbon gases very much in excess, which is what we would expect. To practically demonstrate that the above takes place when asphalt is in contact with illuminating gas, I took two samples of gas from a tap in the laboratory. One was analyzed while the other was kept for several weeks in a tube, the interior of which was coated with asphalt cement such as is used in pavements, after which it was analyzed. The results of the two analyses are here given:

	Original gas.	Gas after asphalt absorption.
Carbon dioxide	0.2	0.1
Oxygen	0.0	0.0
Heavy hydrocarbons	12.1	7.2
Carbon monoxide	25.5	27.3
Hydrogen	39.2	42.2
Methane	23.0	23.2
Nitrogen	0.0	0.0

It is evident from this that the asphalt cement has absorbed over 5% of the heavy hydrocarbon gases, a little methane, and practically nothing else.

I have ascertained by experiment that 1 part by volume of asphalt cement will absorb 42 parts of illuminating gas in somewhat over a month. I have also practically shown that asphalt is much softened by absorbing gas, the ordinary asphalt cement becoming as soft as a thick maltha after being in an atmosphere of illuminating gas for several months. As to the quantity of gas contained in the affected pavements, this of course varies, but in one instance 1,000 cu. cm. of pavement gave off 500 cu. cm. of gas.

There is but one way to stop the disintegration of a pavement from this cause, and that is to stop the leak of gas; for it is useless to patch the pavement, as it will not be long before the patch disintegrates. I have known cases where a pavement so affected was repaired and in 14 months the patches were showing signs of disintegration.

Disintegration by water entering a pavement by oozing up through the base: I believe if more thorough investigation were made into the cause for the disintegrating of pavement, this would be found to be one of the most common, especially in small towns and cities where there are terraces or considerable lawns in front of houses. There have been a number of cases in this city where the water has entered a terrace or parking where they were above the grade of the street and worked its way up through the concrete base to the asphalt surface.

This disintegration manifests itself differently, depending on the character of the pavement. If the asphalt surface is soft or the concrete smooth, the first defect noticed will be the tendency of the pavement to crowd in warm weather. This is due to the under portion of the surface mixture rotting, so to speak, thus destroying the cementing properties of the asphalt. The upper portion, although good, being deprived of the support of the affected mixture under it, will be crowded out by traffic. This crowding is assisted by the concrete base being smooth, and also the bond between the base and binder is destroyed by the moisture.

In cases where the concrete base is rough and the surface mixture hard, the principal disintegration will take place in cold weather, nothing abnormal being noticed until the pavement begins a rapid crumbling away in the affected spot under traffic.

On examining a section of asphalt surface disintegrating from this cause, especially where it has not been going on for too long a time, there will be found a layer of perfectly sound and good material at the surface of the pavement, while underneath the mixture will show evidence of being disintegrated by water—that is, the sand will appear clean and white in spots as though there had been an insufficiency of asphalt cement to cover it. The concrete base under the affected pavement will generally be found damp or even wet. We have prevented the destruction of several pavements from this cause by the use of blind drains put in under the gutter next to the lawn or terrace, and even run herring bone under the pavement.*

This last cause for disintegration would of course not occur in a pavement constructed with an asphalt that was unacted on by water, but water soaking up through a concrete base might injure any pavement by freezing.

*Pavements are also affected as just described by water entering cracks, or joints along car tracks, and working its way between the asphalt surface and concrete base.—Note to author's revised proof, March 24, 1900.

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ADVERTISING RATES: 20 *cents a line. Want notices, special rates, see page XXI. Changes in standing advertisements must be received by Monday morning; new advertisements, Tuesday morning; transient advertisements by Wednesday morning.*

Three weeks ago, in our issue of March 15, we commented on the widely published prospectus of the Tripler Liquid Air Co., in which the public was invited to subscribe for 100,000 shares of the company's stock. From a quarter-page advertisement in New York daily papers on March 26, it appears that 25,000 shares were then still to be had by investors with "money to freeze," as one of our correspondents put it. It is, then, a fair deduction that 75,000 shares had been disposed of. At the published price of $5 per share, this would represent a gross return to the company of $375,000. It would be interesting to know what part of this sum actually reached the treasury of the company, and what part went to pay for the huge amount of advertising which was done, and for commissions to local agents who sold the stock.

The statements made in this advertisement and in a prospectus before us are even more extravagant than those which we commented on three weeks ago. At the outset we are modestly told that the name of Mr. Chas. E. Tripler "is as familiar as those of Watts, Franklin or Edison, and the fame of his discovery is equally as great." The compiler of the prospectus was apparently more familiar with the name of the writer of hymns than with that of the great inventor.

In view of the extravagant and misleading statements concerning liquid air and its applications, which have been so widely and persistently circulated, we have thought it wise to present in this issue some of the actual facts upon this subject as given by a scientist and engineer who is unquestionably one of the highest authorities in this field. We refer to Prof. Carl Linde, whose successful work in the field of mechanical refrigeration is known the world over, and whose success as an investigator and inventor in the field of air liquefaction is attested by the fact that nearly 50 of his machines have been delivered to physical and chemical laboratories, the largest of them having a capacity about three times as great as that of the Tripler "factory" in New York city.

The paper by Prof. Linde on the commercial uses of liquid air was read a short time ago before a prominent German scientific society. It presents so plainly the facts as to the uses of liquid air, and is so great a contrast to the statements in the Tripler prospectus that it has seemed to us worth while setting down some of these statements in parallel columns; which we have done as follows:

Power.

Tripler Prospectus.	Professor Linde.
It is but a question of time when all engines, stationary or locomotive, will utilize liquid air in place of any other motive power now known, and, in cheapness, no other ever discovered can compare with it. The enormous number of vessels using coal as fuel; of locomotives, of engines, producing the power for factories and mills, make the millions of dollars possible saving to the world by the development and application of this new power as simply incalculable. A vessel using 100 tons of coal per day would save $8,000 per round trip across the Atlantic. By utilization of the great preponderance of oxygen contained in liquid air thereby guaranteeing a far higher degree of combustion in coal than is now attained by the most advanced methods, the increase from the present power secured of about 10% is derived to such an extent that the saving in the cost of the fuel will be fully 50%.	From the possibility of using liquid air for motor purposes altogether too far-reaching conclusions have been drawn. We are not speaking here of the perpetual-motion machine of Tripler, the American, who so used three gallons of liquid air in his motor that with the energy thus generated he made seven more gallons; but we speak in earnest of the economical driving of power-generating machines by liquid air. The energy required for liquefaction is theoretically nearly twice, and actually about six times as great as the energy which will be liberated when the liquid evaporates. If we remember that in an engine only a certain part of this energy can be turned into mechanical work, it will need no further explanation to show that only a small percentage of the work required for liquefaction can be recovered in a machine driven by liquid air.

Refrigeration.

In its use as a refrigerant the extent of the saving possibilities of liquid air over ice or ammonia is almost equal to that in power. In the United States alone the cost of refrigeration is estimated at $150,000,000 annually, and a single instance will give some idea of the saving effected by liquid air. The annual transportation of fruit from California to the East involves the use of 10,000 cars with an expenditure of approximately $1,337,500 for ice and freight thereon. The same results can be attained by the use of $27,500 worth of liquid air, showing a saving in one year of $1,310,000. Taking into consideration the further fact that the transportation of fruit is but a very small item in the long list of refrigerating uses, it is again almost impossible to conceive any limit to the profits possible to the producers of liquid air.	Refrigeration by liquid air requires an unreasonable amount of power. The work theoretically demanded by the liquid air machine to perform a given amount of refrigeration is theoretically 17 times as great as the work demanded by an ordinary refrigerating machine to effect the same refrigeration. If we remember further, that the efficiency of the ordinary refrigerating machine is more than twice that of the liquid air machine, it is apparent that a given amount of refrigeration by liquid air requires 40 or 50 times as much work as with the ordinary machines, as long as the temperature desired is not far below the freezing point of water.

The proposal to appropriate $200,000 for surveys for a barge canal to replace the present Erie canal is said to have been shelved in the New York legislature, the political leaders feeling that such an appropriation would be used against them as a campaign argument in the coming election. Whether this report be true or not, it is at least evident that the end of the session is now close at hand, and nothing has been done toward putting the bill for the barge canal survey upon its passage. If the present legislature does nothing for the barge canal enterprise, as now seems likely, it seems very doubtful whether another legislature will show it any more favor. The chances must be reckoned with that in other years one political party may control the legislature and another may hold the governorship, and either party is likely to be as chary in the future as at present of taking any action so sure to arouse public opposition as the espousal of the barge canal enterprise. So far as we have been able to gage public opinion, the manifestations in favor of the barge canal have been confined to commercial organizations in New York city and Buffalo. A journal devoted to booming the latter city recently remarked that the proceeds from the sale of eight dozen eggs would pay the canal taxes on the average farm. The political leaders, however, understand that the farmer has other uses for those eggs; and they are exceedingly disinclined to meddle with them.

The theory that mosquitoes are the cause of malaria appears to be rather a popular fad in scientific circles just now; and like many new things in the scientific world, is being heralded as a discovery before its truth, or the extent of its truth, is proven. The evidence thus far presented appears to show that some of the severe malarial fevers of some portions of the tropics can be acquired from the bite or sting of certain varieties of the mosquito. The evidence that these fevers can be acquired in no other way, however, is by no means complete; and even if it were, there is still wanting evidence that the malaria of temperate climates, which is apparently due to a different organism than the malaria of the tropics, may not be acquired by contact of the lungs or alimentary canal with air or water containing the malarial organism. That this organism may be introduced into the human system by the proboscis of a mosquito, whose home is near the soil and water where malarial germs live, is not at all improbable; but that malaria will disappear with the extirpation of mosquitos does not by any means follow.

THE PREVENTION OF WATER POLLUTION IN NEW JERSEY.

The month which has just closed promises to mark the beginning of a new era in the history of water pollution in New Jersey. On the nineteenth of the month the highest tribunal of the State, the Court of Errors and Appeals, reversed the decrees which had been rendered by the Court of Chancery forbidding the pollution of the Passaic River by the cities of Paterson and Newark. In this latest decision the principle is laid down that in all matters of water pollution the legislature is supreme, subject only to the qualification that non-tidal riparian owners have an inviolable constitutional right to recover damages for depreciation of property through sewage or other pollution. Littoral owners, or those on tidal waters, have no remedy whatever, it appears from the decision, if the pollution in question has legislative sanction. By implication, if not quite directly, the court also held that the legislature has the amplest powers to prohibit and prevent pollution. The idea is certainly conveyed, as applied to tidal streams, and streams not yet polluted; but some little uneasiness has been expressed lest the decision be interpreted to signify that when the legislature has given permission to pollute a stream, and such permission has been exercised by a municipality, subsequent prohibition by the legislature itself is barred, although the polluting party would be liable for damages, if the waters were not tidal.

When this latest decision was handed down there was already before the legislature of New Jersey an amendment to an act of 1899, designed to "prevent the pollution of the waters" of the State, establishing a State Sewerage Commission, and authorizing the creation of sewerage districts and boards to carry out joint sewage disposal works for two or more municipalities. This amended act, with some curtailments, has since become a law, having passed both branches of the legislature without a dissenting vote. Briefly, the amended act confers upon the State Sewerage Commission authority to prohibit the pollution of any of the waters of the State, except the Ocean, the Kill von Kull, Arthur Kill and the Hudson River. If on investigation it finds that such waters are being polluted to the injury of any of the inhabitants of the State, the pollution must be discontinued at such a date, within five years of the order, as the commission may fix. No new sewerage system shall be built hereafter unless the plans for the final disposal of the sewage have

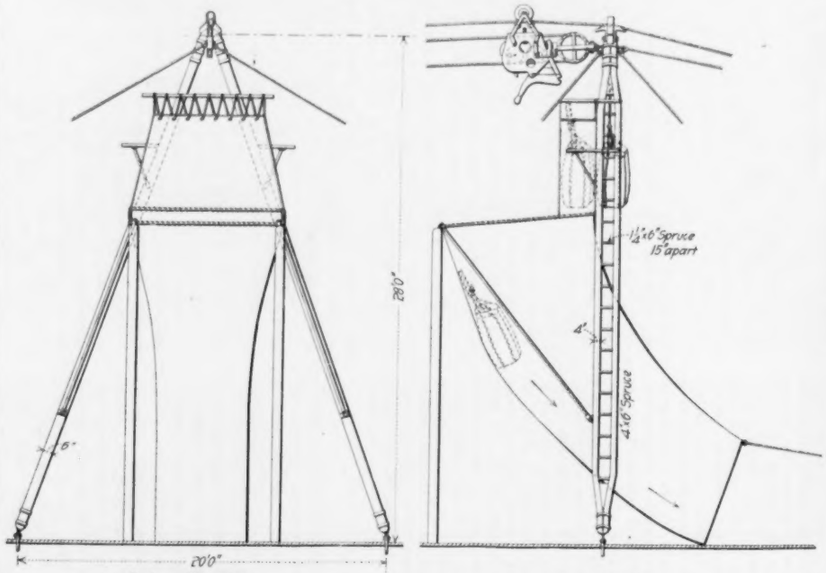


FIG. 3.—DETAILS OF SHEAR LEG CONSTRUCTION ON BATTLESHIP, SHOWING DISCHARGE OF LOAD.

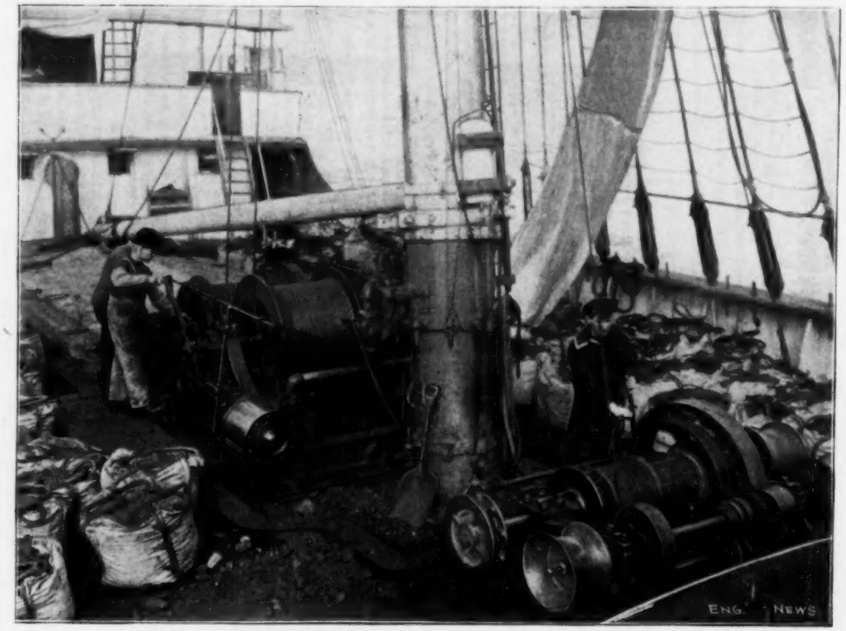


FIG. 8.—VIEW OF DECK OF COLLIER, SHOWING CONVEYOR AND ELEVATOR ENGINES IN OPERATION.

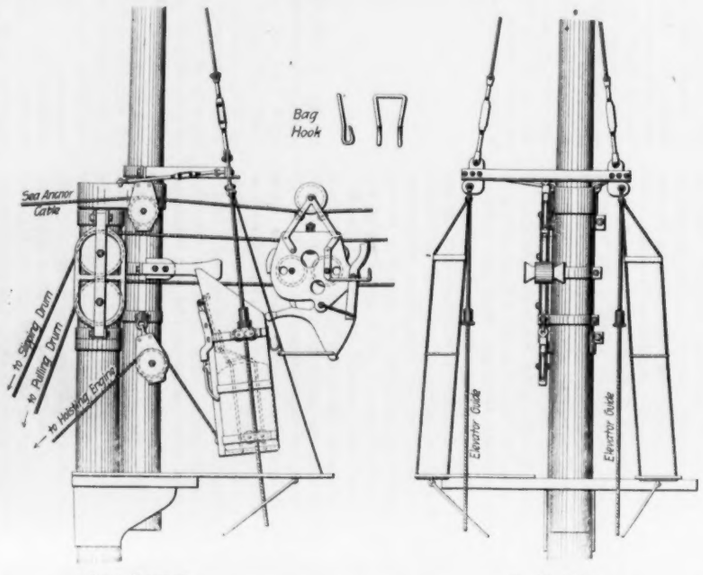


FIG. 2.—DETAILS OF CONSTRUCTION AT MAST HEAD OF COLLIER, SHOWING ELEVATOR AND CARRIAGE IN POSITION FOR LOADING.

FIG. 6.—VIEW OF CONVEYOR CARRIAGE.

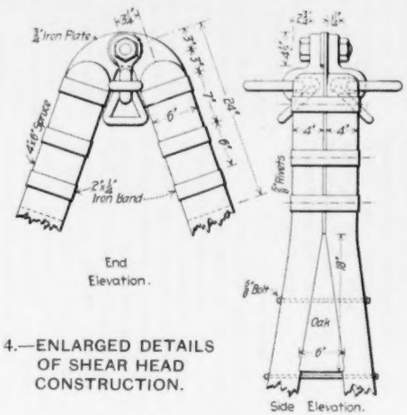


FIG. 4.—ENLARGED DETAILS OF SHEAR HEAD CONSTRUCTION.

THE MILLER CONVEYOR FOR COALING VESSELS AT SEA

Lidgerwood Mfg. Co., New York, Builders.
Spencer Miller, M. Am. Soc. C. E., Inventor.

Side Elevation. End Elevation.

FIG. 2.—DETAILS OF CONSTRUCTION AT MAST HEAD OF COLLIER, SHOWING ELEVATOR AND CARRIAGE IN POSITION FOR LOADING.

FIG. 6.—VIEW OF CONVEYOR CARRIAGE.

Ridgerwood Mfg. Co., New York, Builders.
Spencer Miller, M. Am. Soc. C. E., Inventor.

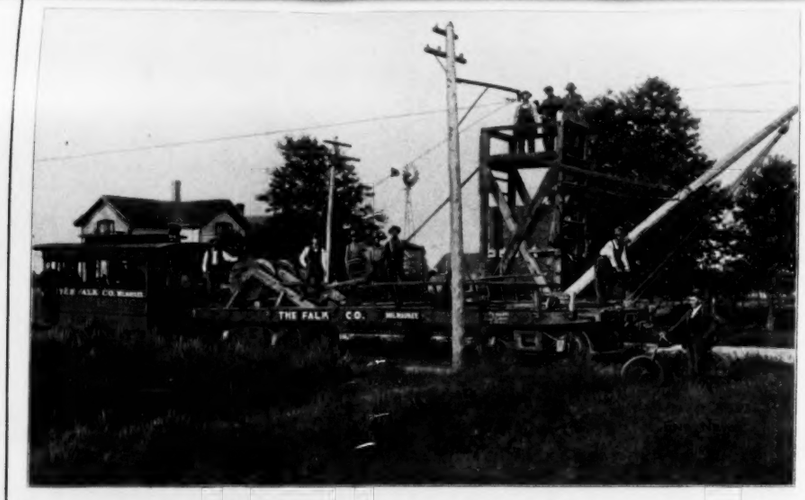


FIG. 6.—TROLLEY-WIRE ERECTING CAR.

FIG. 5.—CONSTRUCTION TRAIN.

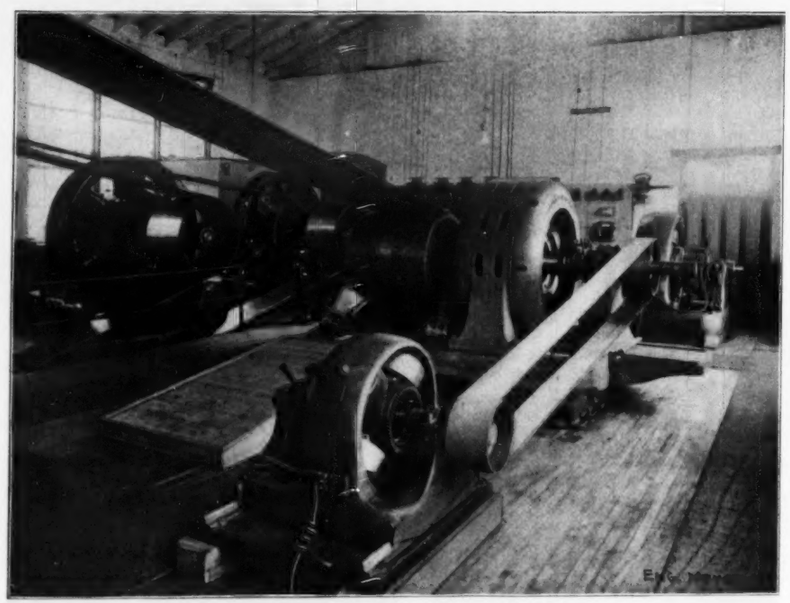


FIG. 7.—INTERIOR OF POWER STATION.

FIG. 1.—GENERAL MAP.

FIG. 2.—VIEW ALONG THE LINE OF RAILWAY.

THE OSHKOSH & NEENAH INTERURBAN ELECTRIC RAILWAY.

E. E. Downs, Vice-Pres. & Gen. Manager.
The Falk Co., Milwaukee, Wis., Contractors.

been approved by the commission, and no sewage disposal works for existing systems shall be built without like approval. The rulings of the commission, at least its prohibitions of existing pollution, are subject to review by the Court of Chancery.

The primary object of both the original and the amended acts being the prevention of the pollution of the Passaic River, for which joint action by several municipalities seems to be desirable, the act provides an elaborate plan for the organization of sewerage districts and boards to carry out disposal works, their formation to be under the supervision of the State Sewerage Commission and their final plans to be subject to the approval of that body. With this part of the act we need not concern ourselves, further than to say that it was amended by the present legislature to make necessary the consent of each municipality before it could be included in a proposed district, instead of the consent of three-fourths of the municipalities concerned. This amendment has been severely criticised, as almost nullifying the objects of the bill, so far as the Passaic River is concerned, since all but one of the communities contributing to the pollution of that stream have appeared to be willing to adopt a plan for joint sewage disposal, and that one has been the city of Paterson, the arch offender in the pollution of the river. We do not see, however, as this change in the act is as serious as has been represented, for under the new law if Paterson is ordered to stop polluting the river it must do so, and its plans to that end must be such as will meet the approval of the State Sewerage Commission. If it chooses to work alone, rather than in co-operation with its neighbors, the chances are that it will be the chief sufferer, if any one suffers, since the principal disadvantage of independent rather than joint action is likely to be the increased cost, which will fall more heavily on Paterson than on any other community. We are, of course, assuming that the commission will hold Paterson to a proper scheme of disposal, in any event. We have heard of no reason why it should discriminate in its favor. Of course, if Paterson is disposed to contest the execution of the law it may possibly be able to cause more delay than if its standing out was blocking the execution of works for the whole valley, but inasmuch as the court has pronounced in clear and forcible terms that Paterson is liable to the riparian owners for damages on account of discharging its sewage into the river, and that city has already hurt its standing among the river towns by its past opposition, it seems only reasonable to expect that it will speedily fall into line.

From the standpoint of the State as a whole, the amendment excluding the waters of the Ocean, the Kill von Kull, the Arthur Kill and the Hudson River from the jurisdiction of the commission is, perhaps, more serious than the amendment just discussed, which simply leaves each municipality free to act independently or jointly in carrying out new disposal works. But the exempted waters are all tidal, of large or comparatively large volume, and their pollution can rarely if ever result in injury to public health. Moreover, any pollution of these waters will generally affect chiefly the communities causing the offence, real or alleged. If the act as passed proves beneficial to inland places, the municipalities adjacent to the exempted waters will claim protection in due time, as the pollution increases.

It will be seen from the above that the legislature has clothed the State Sewerage Commission with ample powers, and the courts have so ruled that these powers can be freely exercised in the prevention of stream pollution. One thing more is necessary, however, and that is the provision of funds to enable the commission to carry on its work. This is virtually the fifth State Sewerage Commission which the New Jersey legislature has created. Of the four preceding commissions, only the first was provided with funds for its work. The small expenses incurred by the third commission were paid from the private purses of some of its members, who were reimbursed subsequently from the yearly emergency appropriations, and given a small salary in addition. The members of the fourth commission were originally to have salaries of $1,500 a year each, besides which they were authorized to expend in 1899 such a sum as the legislature might appropriate, not to exceed $5,000, but the legislature provided nothing whatever, as we understand it, so the commissioners were not only called upon to await the pleasure of the next legislature for salary, but had to rely on the Governor's emergency fund for such petty expenses as stationery and office rent. Obviously, the usefulness of any such commission depends largely upon its ability to procure competent expert advisers upon both the engineering questions and the legal questions involved. The primary object of the commission, as we have already said, is to aid in solving the problem of preventing the pollution of the Passaic River, a problem involving the expenditure of millions. The final plans for this work, as well as for all other sewage disposal plants in the State, must be approved by the commission; and, besides that, the commission has authority to declare, if, in accordance with its judgment, that nearly all the sewerage systems of the State are polluting the waters receiving the sewage, and that the pollution must be stopped. There were no engineers on the commission appointed in 1899. If the members of that body do not hold over under the amended act, just become a law, very likely they will be reappointed. Their avocations are as follows: Newspaper editor, physician, brewer and lawyer, there being two of the latter. Without any disparagement to the commission, it is evident that it must have competent engineering advice if it is to cope adequately with the problems before it; and it is equally evident that such advice is not likely to be secured unless the legislature has provided funds for the commission. It is sincerely hoped that money will become available for the work, for the rapid increase in the pollution of the waters of the State demands immediate and well-considered action, besides which there is a strong feeling in the Passaic valley that the people there are being fed on vain promises.

We will now revert to the recent decisions of the New Jersey Court of Errors and Appeals, which contain some points of great interest. The gist of the Paterson and Newark decisions were given in the opening paragraph of this article. The decision of the Paterson case in the Chancery Court was abstracted pretty fully in our issue of March 9, 1899, and we published a brief note on the original Newark decision in our issue of March 16, 1899 (p. 167). The suit against Paterson was brought by riparian owners above tide-water, and was joined in by Jersey City, which claimed that the pollution was in violation of its rights to take water from the Passaic River to supply its inhabitants. The Chancery Court enjoined the city from constructing any more sewers, but did not interfere with those already in use, pending the final hearing. The Newark suit was brought by a manufacturing concern in the city of Newark, with property on the water front, just below the outlet of a proposed new relief sewer. The plaintiff contended that the proposed discharge of sewage would injure its business, and the health of its employees. The construction of the sewer was forbidden. The judges in the two Chancery cases were not the same. The Court of Errors and Appeals reversed the two decisions by a vote of 11 to 1. The syllabus in the latest Paterson decision was as follows, the suit being entitled, Attorney General ex rel. Henry P. Simmons et al. vs. the Mayor of the City of Paterson:

(1) The city of Paterson had legislative authority to construct its system of sewers, discharging their contents into the Passaic River, and it is not therefore subject to the charge of maintaining a public nuisance.

(2) The title of the riparian owners along the Passaic River where the tide ebbs and flows extends only to high water. The state is the absolute owner of the bed of the stream. Such riparian owners, having no titles to the bed of the stream, are not entitled to an injunction against the city on account of the pollution of the stream.

(3) The title of the riparian owners above the ebb and flow of tide extends to the middle of the stream, subject only to a servitude to the public for the purposes of navigation. The pollution of the river by sewage constitutes the taking of the property of such owners which the legislature cannot authorize except upon just compensation.

(4) Jersey City has no rights in the waters of the Passaic River distinct from the rights of the general public, either by reason of the location of its water-works or in virtue of the act of 1852.

(5) By reason of the great injury which would fall upon the city by restraining the continuous use of its sewerage system, and the acquiescence of these riparian owners above where the tide flows, their injury being comparatively small, it would be inequitable to grant them an injunction.

(6) They may obtain redress by amending their bill, or by filing a new bill praying for an injunction unless the city of Paterson will consent to make such compensation to them as shall be ascertained to be just; or they may, if they elect, sue at law for their damages.

The syllabus in the case of the Marcus Sayre Co. against the city of Newark was as follows:

The legislature of this state has constitutional power to confer on municipalities the right to use the tidal streams within our borders as outlets for public sewers carrying off surplus water and the sewage from buildings.

The charter of the city of Newark grants to the municipal authorities of the city the right to use the Passaic River as such an outlet. The fact that such a use of the Passaic River pollutes the water and air in the neighborhood of a dock on the river owned by private persons, and thus lessens the value of private property, will not justify an injunction to restrain the city from constructing and operating a sewer which the municipal authorities have, within the limits of their legal discretion, determined to be necessary for sewerage purposes.

From these quotations it will be seen that the court allows absolutely no redress to owners of property abutting on the tidal portion of the river for damages caused by sewage turned into the stream under legislative sanction. Worse yet is the bearing of the decision on public water supplies, but fortunately there are comparatively few supplies taken from tidal streams. The amplification of paragraph (4) of the Paterson syllabus is a narrow and technical view of a life and death matter, for here the court, in effect, goes so far as to say that the legislature had a perfect right to authorize the pouring of poison into the water supply of Jersey City if it saw fit, the language being as follows:

At the time of the legislative grants to the city of Paterson in 1867, 1868 and 1871, it would have been competent for the legislature to pass a law prohibiting the further use of the Passaic water in Jersey City and compelling the city to procure its water elsewhere. Therefore the grant to Paterson must be regarded as a repeal by implication of the previous grant to Jersey City, if there was an impairment of that grant, which cannot be conceded. Jersey City is without a standing to invoke the injunction power in this case.

Had the legislature actually passed an act estopping Jersey City from taking the Passaic water supply, the case would have been different, as a matter of common sense, if not common law or equity; but to say one year that a city might take water from a stream, and after it had expended hundreds of thousands of dollars to that end, and its inhabitants were dependent upon the stream for life and health, to deliberately say to another city, you may pour as much poisonous sewage into that stream as you wish, giving the first city no warning and no time to change its source of water supply, ignores the most elementary principles of sanitation, and shows an utter disregard of the value of human life. To be sure, the court heaps all the opprobrium of such action on the legislature, but we are confident the time will come, even in long-suffering New Jersey, when some share of the opprobrium will fall on a court that holds a legislature has such powers. Had the court said the Passaic River was now so badly polluted as to be unfit for use as a water supply, or, in other words, that the appeal for relief had been too long delayed, its opinion would have been less at variance with sanitary science, but it holds that any time after granting Jersey City the right to take water from the Passaic the legislature could authorize another city to make that supply not only worthless, but positively dangerous to life. Neither property nor life on the lower Passaic, the court says, have any constitutional protection against the pleasure of the New Jersey legislature, simply because that portion of the river is a tidal stream, and "the State is the absolute owner to the bed of the stream."

The riparian owners on the non-tidal portion of the river fare much better, for they have a right to compensation for their property, although they cannot bring action for "maintaining a public nuisance." That is, they must flee, if necessary, in order to save their lives, but they may recover such damages as they can prove on account of the property left behind them.

We have tried to bring out some of the most objectionable phases of these decisions because they seem something like a return to the dark ages, and appear to be in the strongest contrast with recent decisions in other States, notably in Connecticut, as will be seen on reading the summary of the case, "Platt et al. vs. City of Waterbury," given elsewhere in this issue under "Legal Decisions of Interest to Engineers." We do not pretend to be writing as lawyers or judges, but from the stand-

point of recent ideas on engineering and sanitation. We confess, however, to a feeling that the court is technically correct in all its rulings, unless it really means to maintain that life and property on a tidal stream is wholly at the mercy of the legislature.

It might be salutary if the decisions were both taken to the United States courts. Weaker cases have gone there on the claim of the failure of State courts to protect life and property, both of which are involved here. The defendants would doubtless file a demurrer, claiming that the United States courts had no jurisdiction, which would immediately raise the most serious question involved, whether life and property were in danger of being taken without due process of law.

Whatever other uncertainties there may be regarding these decisions, they throw a searchlight on the past course of the New Jersey legislature, revealing the fact that, barring the possible virtues of recent enactments, that body has done nothing, or next to nothing, to protect the purity of the waters of the State. Although not brought out in the decision, it is a fact that although legislation to prevent river pollution has been sought for many years in New Jersey, it was only a short time since that the one meager and contradictory law on the New Jersey statute books for the protection of its public water supplies was carefully restricted to brooks, ponds and creeks, thus excluding the Passaic and all the other rivers of the State.*

Surely a commonwealth under such conditions, during many years of rapid town and city growth, has forfeited some of the rights to that noble name and has need of a State Sewerage Commission with the most ample powers and liberal appropriations. We trust the legislature has provided or will provide the commission with both the latter, and that when its powers come before the courts for review it will not be found that the legislature is still dallying with the health and property of the people in the interests of water syndicates and political magnates, or in the vain attempt to appease sectional jealousies. We also hope that the courts of New Jersey will not again make themselves the laughing stock of the sanitary world as one of them did in 1889, when it declared that the sewage of Paterson had so far been purified in a flow of 4½ miles down the Passaic River as to be probably only an alleged danger to the water supply of Newark. It was thought that this stigma on the New Jersey courts had been removed by the decision of the Court of Chancery, reviewed in our issue of March 9, 1899, but 11 out of 12 judges of the Court of Appeals have taken at least a partial step backward to the position of eleven years ago, when Newark unsuccessfully attempted to restrain the city of Passaic from discharging its sewage into the Passaic River four or five miles above the intake of the Newark water-works. The court then declared it could do nothing to protect the public water supply of a large city, and the higher court now says the same, simply because the State owns the bed of tidal streams. The legislature flatly refused all relief until both Newark and Jersey City had contracted with private water companies for a supply from other sources than the lower Passaic. At last it seems to have placed the State well in the van of those commonwealths that are guarding their inland waters, so we may hope to forget the darkness of the past in the brightness of the future of the prevention of water pollution in New Jersey.

LETTERS TO THE EDITOR.

The Distilling Machinery Used in United States Naval Vessels.

Sir: In your valued paper of March 29, I note a description of a distilling apparatus. In this description you make mention of the U. S. Navy distilling ship "Iris," and the natural inference would be that the apparatus in this vessel was designed and built by the parties whose machine you are describing. The facts are, the distilling apparatus for the distilling ships "Iris," "Rainbow" and "Vulcan" were built by me, as also the distilling apparatus for about 100 other naval vessels. The army transport "Sumner" has also a 10,000-gallon or 50-ton machine, which was built by me.

Very truly yours, M. T. Davidson.

43 Keap St., Brooklyn, March 30, 1900.

*See Eng. News, Jan. 31, 1891, "Regulations Concerning the Pollution of Streams in New Jersey"; a report by a committee of the New Jersey Sanitary Association, C. P. Bassett, M. Am. Soc. C. E., Chairman.

A Method of Making a Farm Survey.

Sir: I have been much interested in reading the article "A Method of Making a Farm Survey," by Mr. G. B. Zahniser, in your issue of this date. The detail as worked out by Mr. Zahniser strikes me as excellent. It may interest Mr. Zahniser and others to know that this same general method is found described in Raymond's "Plane Surveying," as is also the detail of the systematic office work. I believe also that Mr. Zahniser will find Crockett's tables, published separately, or with Crockett's Trigonometry, or with the text-book of surveying mentioned, fully equal to Gauss for rapidity of work.

Troy, N. Y., March 29, 1900. W. G. R.

The Rusting of Steel Nails.

Sir: Have you had your attention called to difficulties from the rusting of steel nails used for outside work? In this vicinity steel nails—both wire and cut—have been largely used in recent years, especially for shingling. Experience shows that these steel nails quickly rust off close to the boarding; the shingles blow off; and, in from three to nine years, the buildings have to be reshingled, although the shingles themselves are worn scarcely at all. Wrought-iron nails driven 60 years ago in outside work are still in a good state of preservation. There seems to be no doubt, therefore, that the steel is not nearly as durable, when exposed to the weather in this climate, as is wrought iron. I would like to know if the same experience has been had in other parts of the country? Or, is the damp, foggy climate of the Maine coast responsible for the rapid corrosion of the steel nails?

Yours truly,

Macy S. Pope.

East Machias, Me., March 28, 1900.

(The very rapid corrosion of the steel nails is doubtless due to the climate; but the fact that steel corrodes more rapidly than wrought iron in any locality is now pretty well known. As some difficulty would probably be found in procuring nails made from wrought iron, the use of copper nails for shingling would perhaps be the most available remedy.—Ed.)

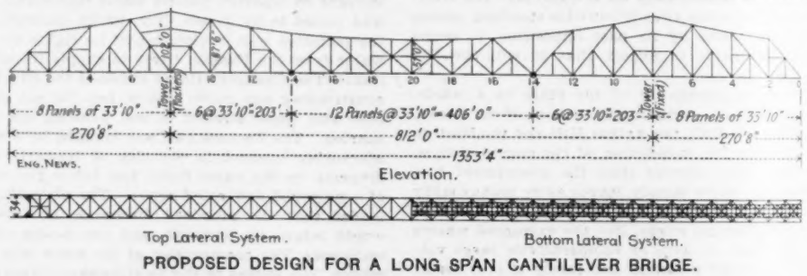
A Proposed Design for a Long-Span Cantilever Bridge.

Sir: The accompanying sketch shows one of several proposed designs made by me last summer for a cantilever bridge. I should be pleased if some of your readers would express an opinion in reference to the practicability and advisability of such a design for a long span and also for a short span cantilever bridge. The bridge would be fixed on the east tower and rest on the rollers on the west tower. It would be erected by setting the west half on the rollers nearer the shore than its final position, and making the center connection by pulling the parts together with turnbuckles. The top chords from 12 to 16 are adjustable and are fitted to take tension, but not compression, and after erection will take tension only when one panel point 14 sinks more than a certain amount below the corresponding panel point at the other end of the suspended span. The rollers would be similar to those designed by Mr. Geo. S. Morison for the middle pier of the Memphis bridge check bars being used to prevent any accident to the rollers. The method of making the center connection is simple, and the continuous floor system makes the bridge stiff laterally.

The adjustable members of the top chord, if considered advisable, can be so arranged as to increase the vertical stiffness of the bridge by reducing the deflections at the ends of the suspended span, the frequency and amount of these deflections being one of the objections to a cantilever bridge. The suspended span and the adjustable top chords can be so arranged that, in case of excessive deflection occasioned by the injury of one of the members of the suspended span, the bridge would act as a cantilever all the way from each tower to the injured member. This method of erection is similar to the method used for the erection of the Northfield bridge over the Connecticut River, as described in Engineering News, Sept. 7, 1899. The Northfield bridge was a lighter bridge, but was loaded with about 340 tons of sand and was connected in about 2½ hours without any trouble whatever. From my experience on that bridge I should myself consider this design and this method of erection to be good. Very truly,

J. Carrier.

147 West 21st St., New York, N. Y., March 2, 1900.



PROPOSED DESIGN FOR A LONG SPAN CANTILEVER BRIDGE.

Checking Multiplication and Division by Casting Out the 11's.

Sir: A method of casting out the 11's by which each and every step of the operation may be very easily checked may be interesting to some of your readers as it avoids the practical necessity of waiting for the entire completion of the computation. The fundamental principle is very important, and is easily demonstrated mathematically, but I will not occupy space by doing so, as it will be much clearer by an example, especially when we come to the application.

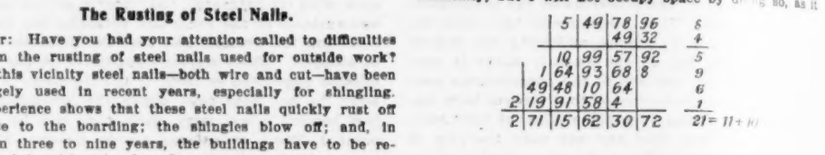


Fig. 1.

Let the remainder left after casting out the 11's out of any number be called the E of that number. Then the E of 5,497,896 is also the E of the sum of the numbers 5, 49, 78 and 96. The work will be much shortened if we find E of each of these component members separately; thus, 5 + 5 + 1 + 8 = 19 = 11 + 8. Hence 8 is the E of 5,497,896. The operation of multiplying 5,497,896 by 4,932 is shown in Fig. 1. The operation of checking is conducted as follows, the E's being set off on the right: 2 × 8 = 16 = 11 + 5, and 5 is the E of 10,995,792. The E of 30 is 8, and 8 × 8 = 64 = 55 + 9, and 9 is the E of 164,936,880. (We add a cipher because the last figure on the right is to the right of the vertical line.) Again, 9 × 8 = 72 = 66 + 6, and 6 is the E of 49,481,064. The E of 40 is 7, and 7 × 8 = 56 = 55 + 1, and 1 is the E of 219,915,840.

The detailed process of checking the division of 5,497,896 by 163, giving a quotient of 33,729 and a remainder of 69, is shown in Fig. 2. The numbers written above the quotient are explained as follows, viz.: 3 is the E of 3; 0 is the E of 330; 7 is the E of 337; 5 is the E of 33,720; 3 is the E of 33,729. The remaining figures are explained as follows: 9 is the E of 163 and is written above it. The figures written in the vertical column, viz., 8, 5, 3, 6, etc., are the E's of the numbers to the right of them. Now proceed to check. 3 (above the 3 in the quotient) × 9 = 27 = 22 + 5, and 5 is the E of 489, and 8 − 5 = 3, and the latter is the E of 607,896. The E of 30 (in 37 in the quotient) is 8, and 8 × 9 = 72 = 66 + 6, and 6 is the E of

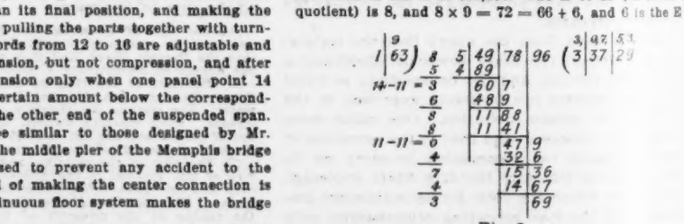


Fig. 2.

4,890. 3 + 11 = 14, and 14 − 6 = 8, which is the E of 118,896. To prove this, take the figure 0 above the quotient; then 0 × 9 = 0, and 8 − 0 = 8. Again, 7 (in the quotient) × 9 = 63 = 55 + 8, and 8 is the E of 1,141, and 8 − 8 = 0, which is the E of 4,796. To prove this, 7 (above the quotient) × 9 = 63 = 55 + 8, and 8 − 8 = 0. Again the E of 20 (in 29) is 9, and 9 × 9 = 81 =

77 + 4, and 4 is the E of 3,260; 11 + 0 = 11, and 11 − 4 = 7, and the latter is the E of 1,536. To prove this, 5 (above the quotient) × 9 = 45 = 44 + 1, and 8 − 1 = 7. Again 9 (in the quotient) × 9 = 81 = 77 + 4 and 4 is the E of 1,467, and 7 − 4 = 3. To prove this, and also give the final check, 3 (above the quotient) × 9 = 27 = 22 + 5, and 8 − 5 = 3. It will be noticed that figures to the right of a vertical line are considered, for the purpose of finding the E, as occupying the tens place, and those on the left the units place.

Fig. 3 shows the method of procedure when the vertical lines cut off only one figure on the extreme right of the first partial product (5,088 in this case) and consists

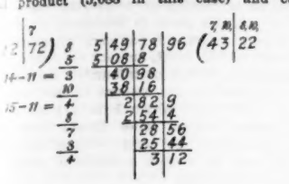


Fig. 3.

merely in cutting off the first two figures on the extreme left of the quotient instead of one as in the previous example. In order to prevent any possible confusion of figures it may be necessary to explain that this figure (Fig. 3) is the division of 5,497,896 by 1,272 giving a quotient of 4,322 and remainder of 312. No other explanation is necessary as the rest of the procedure is the same as Fig. 2.

The method may be applied also to the extraction of the square or cube root and every step checked; but it is hardly necessary to give detailed explanations here. I have found it very convenient in my own practice, especially where great accuracy is required, and more soothing than a headache powder. The figures representing the E's should be written, either with different colored ink, or a pencil of different hardness or softness from the writing tools with which the calculation is performed.

Yours truly, C. H. Lindenberger.

89 Park Ave., Detroit, Mich., March 14, 1900.

A Method for Checking Addition.

Sir: The writer makes no claims to originality for the following method for checking addition, but, as he has found it to be simple and reliable, he thinks it may be of some value to your readers.

Having found the sum of a column of figures it is desired to check the addition.

Beginning from the right hand side add crossways the alternate digits of the columns, as a b c d e, etc.; from this sum subtract the sum of the remaining alternate figures, as f g h i, etc. If the second sum is greater than the first, increase the first sum by enough elevens to make the first sum greater than the second. Subtract the second sum from the first and place the differences thus found in a column for addition. Add these differences and subtract the sum of the second alternate from the sum of the first alternate figures, increasing if necessary the sum of the first alternate figures by sufficient elevens to make said sum greater than the sum of the second alternate figures. The difference thus found is equal to the difference found by subtracting the sum of the second alternate figures from the sum of the first alternate figures (increasing the sum if necessary by sufficient number of elevens) of the answer of the column of figures, and gives the desired check:

e	l	d	h	c	g	b	f	a		R
7	6	5	4	3	2	1	2	5	21 − 14 =	7
8	0	2	4	6	8	0	4	8	24 − 16 =	8
3	6	9	2	5	8	1	4	7	25 − 20 =	5
4	8	2	8	0	9	8	9	6	20 + (2 × 11) = 42 − 34 =	8
3	6	9	2	5	8	1	4	7	25 − 20 =	5
2	9	6	8	0	9	4	6	8	20 + (2 × 11) = 42 − 32 =	10
5	9	6	9	1	8	6	5	3	21 + 11 = 32 − 31 =	1
6	2	8	4	0	6	3	1	7	24 − 13 =	11
7	3	9	5	1	7	3	9	5	25 − 24 =	1
8	1	4	7	0	7	4	1	8	24 − 16 =	8
9	2	3	5	7	9	1	3	5	25 − 19 =	6
4	1	8	5	2	9	6	3	0	20 − 18 =	2
	9	0	8	0	8	0	9	0	(11 × 4) = 44 − 34 =	10
7	2	9	8	5	0	2	4	6	9	23 + 11 = 34 − 29 = 5	82

2 + 11 = 13, − 8 = 5 }
23 + 11 = 34, − 29 = 5 } check.

Warren R. Borst.

191 Hamilton St., Albany, N. Y.

(For the delectation of those of our readers who have the time and inclination to trifle with such matters, we append the following proof of the above method:

Let,

N = a number,

d_0, d_1, d_2, etc., = its digits,

D = the difference between the even and odd digits, and

R = radix of the system of numeration used (= 10 in the ordinary system);

then,

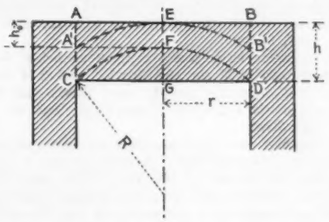
$$N = d_0 + d_1 r + d_2 r^2 + d_3 r^3 + \ldots$$
$$D = d_0 - d_1 + d_2 - d_3 + \ldots$$
$$N - D = d_1 (r + 1) + d_2 (r^2 - 1) + d_3 (r^3 + 1) + \ldots ;$$

therefore, N − D is divisible by r + 1, and, if D is divisible by r + 1, so, also, is N. If D is not so divisible, the remainder from its division will equal the remainder from the division of N as long as D is positive. It is a negative, and is subtracted from r + 1, or the multiple of r + 1 numerically next greater than D, the remainder will equal that arising from the division of N. We see, then, that the quantities in column R represent the remainders from the division of the respective numbers in the column to be added. In this connection the remainder 11 given might as well have been omitted. Now, the sum of the large column may be considered to consist of some number of elevens plus a remainder equal to the sum of column R. The latter two quantities mentioned should, of course, exceed a multiple of eleven by the same amount, which furnishes the desired check. This method obviously fails when an error is made of a whole eleven. For our part we do not see that the method is shorter, and is certainly far from being as simple as the ordinary method of adding the column in reversed order, which furnishes a very certain check.

A proof similar to the above may be applied to the method for checking multiplication by casting out the elevens, given by Mr. Lindenberger; but here again we may remark that, the slide rule, the use of logarithms, or even the repetition of the process with the multiplier and multiplicand transposed, seem to us more practical and convenient methods for the busy computor.—Ed.)

Stresses in Circular Plates.

Sir: I have read with much interest the discussion on stresses in circular plates between Mr. Edward Godfrey and Professors Lanza and Church, in your issue of March 8, and beg a little space to show a method I employed about four years ago to find a rational formula by which I could compute with safety the thickness of circular plates fixed all around, uniformly loaded, a problem which I had to solve in designing d'Auria pumping engines.



Let A B D C be a flat circular plate of thickness h and radius r, fixed all around. With any radius R describe a spherical segment C F D, so that the point F is below the point E of the plate, and with the thickness E F = h_0 describe the spherical segment A' E B' D F C. Putting $FG = \frac{h}{n}$, and denoting by f the working strength per unit area, and by p the load per sq. in., we get

$$h_0 = \frac{n-1}{n} h = \frac{R p}{2 f}. \qquad (1)$$

The value of R is given by

$$R^2 = r^2 + \left[R - \frac{h}{n}\right]^2,$$

from which we get

$$R = \frac{h^2 + n^2 r^2}{2 h n}. \qquad (2)$$

In order to get out of the flat plate the spherical segment of greatest strength we have to make

$$\frac{2 \pi R h_0 f}{\pi R^2 p} = \text{maximum},$$

or,

$$\frac{h_0}{R} = \frac{n-1}{h^2 + n^2 r^2} = \text{maximum},$$

which gives

$$n = 1 + \sqrt{1 + \frac{h^2}{r^2}}.$$

Substituting this value in (1) and (2), and solving for p, we get

$$p = \frac{2 f h^2}{r^2 + r^2 \sqrt{1 + \frac{h^2}{r^2}}}.$$

Neglecting $\frac{h^2}{r^2}$, we can write approximately

$$p = \frac{f h^2}{r^2}; \qquad (3)$$

or,

$$h = r \sqrt{\frac{p}{f}}; \qquad (4)$$

and also $h_0 = \frac{1}{2} h$.

The additional strength contributed by the metal left above and below the spherical segment of thickness h_0 is practically equivalent to that of a flat plate of thickness $h_1 = \frac{1}{2} h$, which plate, treated in the same manner as the original one, would give

$$p_1 = f \frac{h_1^2}{r^2} = f \frac{h^2}{4 r^2} = \tfrac{1}{4} p,$$

plus the strength derived from a flat plate of thickness $h_2 = \frac{1}{2} h_1 = \frac{1}{4} h$. Carrying this process ad infinitum we would get

$$p_2 = f \frac{h_2^2}{r^2} = (\tfrac{1}{4})^2 p;$$

$$p_3 = f \frac{h_3^2}{r^2} = (\tfrac{1}{4})^3 p;$$

$$\ldots\ldots\ldots\ldots\ldots$$

$$p_n = f \frac{h_n^2}{r^2} = (\tfrac{1}{4})^n p.$$

Hence, the total pressure per sq. in. which the original plate can support is

$$\Sigma p = P = f \frac{h^2}{r^2} [1 + (\tfrac{1}{4}) + (\tfrac{1}{4})^2 + (\tfrac{1}{4})^3 + \ldots + (\tfrac{1}{4})^n]$$

which for $n = \infty$, gives

$$P = \frac{4}{3} f \frac{h^2}{r^2}, \qquad (5)$$

or

$$h = r \sqrt{\frac{3}{4} \frac{P}{f}}. \qquad (6)$$

The formula given by Professor Lanza is

$$h = r \sqrt{\frac{2}{3} \frac{P}{f}},$$

which is less than 6% below the value given by my formula.

For a circular plate, supported all around, Professor Lanza gives

$$h = r \sqrt{\frac{5}{6} \frac{P}{f}},$$

and the mean between this and the preceding value is

$$h = r \sqrt{\frac{2.25}{3} \frac{P}{f}} = r \sqrt{\frac{3}{4} \frac{P}{f}},$$

which is exactly the value given by my formula.

Sincerely yours, Luigi d'Auria.

Drexel Building, Philadelphia, Pa., March 10, 1900.

What is the Value of Extra Pressure in a Water Supply for New York City.

Sir: Having called your attention to the impropriety of contrasting, in matter of cost, an additional water supply for New York city at a pressure of 300 ft., with the present supply having a maximum pressure of 100 ft. (Eng. News, March 22, p. 194), you reply that 300 ft. pressure is no good anyway, and that New York having commenced as she did, has got to keep on with no water above the second floor in a vast territory, hardly any real water pressure downtown, none for the tall buildings, and no adequate fire protection in the dry-goods district, and that tens of thousands of pumps run uptown and downtown by private parties isn't so bad a makeshift for a public water supply for the metropolis after all. The laying of special high pressure mains in high pressure districts, for those who want and need the high pressure, is the system in use in scores of cities, and the fact that the New York high pressure districts would not themselves be on a materially higher elevation above tide than the low pressure districts, would form no objection to the plan. Of course we all know that even low pressure street mains are tested to nigh 700 ft. pressure, but then there is the plumbing in the houses. Either improved plumbing, or pressure regulators at $4 or $5 each, "20% off," for each weakly plumbed house, might be used to protect the plumbing, but perhaps you are right. There is a lot to be said in favor of the old way, even if it is stupid and an imperfect one, and it is, at all events, much easier to keep on following it.

You also demonstrate that contracts could be let to give forever the water now supplied to New York city 200 ft. more pressure, for from $4 to $7 per million gallons. Perhaps so, though I think $10 would be nearer the mark, when all sorts of fixed charges are included, besides mere operation; provided the contractor had the water within the city limits to elevate. But has he? Or has the city? More than that: where can anyone go to repeat the comparatively simple and inexpensive operation of bringing in the water of the Croton River? Having got the comparison from: as $36 is to $70, up to: as

point of recent ideas on engineering and sanitation. We confess, however, to a feeling that the court is technically correct in all its rulings, unless it really means to maintain that life and property on a tidal stream is wholly at the mercy of the legislature.

It might be salutary if the decisions were both taken to the United States courts. Weaker cases have gone there on the claim of the failure of State courts to protect life and property, both of which are involved here. The defendants would doubtless file a demurrer, claiming that the United States courts had no jurisdiction, which would immediately raise the most serious question involved, whether life and property were in danger of being taken without due process of law.

Whatever other uncertainties there may be regarding these decisions, they throw a searchlight on the past course of the New Jersey legislature, revealing the fact that, barring the possible virtues of recent enactments, that body has done nothing, or next to nothing, to protect the purity of the waters of the State. Although not brought out in the decision, it is a fact that although legislation to prevent river pollution has been sought for many years in New Jersey, it was only a short time since that the one meager and contradictory law on the New Jersey statute books for the protection of its public water supplies was carefully restricted to brooks, ponds and creeks, thus excluding the Passaic and all the other rivers of the State.*

Surely a commonwealth under such conditions, during many years of rapid town and city growth, has forfeited some of the rights to that noble name and has need of a State Sewerage Commission with the most ample powers and liberal appropriations. We trust the legislature has provided or will provide the commission with both the latter, and that when its powers come before the courts for review it will not be found that the legislature is still dallying with the health and property of the people in the interests of water syndicates and political magnates, or in the vain attempt to appease sectional jealousies. We also hope that the courts of New Jersey will not again make themselves the laughing stock of the sanitary world as one of them did in 1889, when it declared that the sewage of Paterson had so far been purified in a flow of 4½ miles down the Passaic River as to be probably only an alleged danger to the water supply of Newark. It was thought that this stigma on the New Jersey courts had been removed by the decision of the Court of Chancery, reviewed in our issue of March 9, 1899, but 11 out of 12 judges of the Court of Appeals have taken at least a partial step backward to the position of eleven years ago, when Newark unsuccessfully attempted to restrain the city of Passaic from discharging its sewage into the Passaic River four or five miles above the intake of the Newark water-works. The court then declared it could do nothing to protect the public water supply of a large city, and the higher court now says the same, simply because the State owns the bed of tidal streams. The legislature flatly refused all relief until both Newark and Jersey City had contracted with private water companies for a supply from other sources than the lower Passaic. At last it seems to have placed the State well in the van of those commonwealths that are guarding their inland waters, so we may hope to forget the darkness of the past in the brightness of the future of the prevention of water pollution in New Jersey.

*See Eng. News, Jan. 31, 1891, "Regulations Concerning the Pollution of Streams in New Jersey"; a report by a committee of the New Jersey Sanitary Association, C. P. Bassett, M. Am. Soc. C. E., Chairman.

LETTERS TO THE EDITOR.

The Distilling Machinery Used in United States Naval Vessels.

Sir: In your valued paper of March 29, I note a description of a distilling apparatus. In this description you make mention of the U. S. Navy distilling ship "Iris," and the natural inference would be that the apparatus in this vessel was designed and built by the parties whose machine you are describing. The facts are, the distilling apparatus for the distilling ships "Iris," "Rainbow" and "Vulcan" were built by me, as also the distilling apparatus for about 100 other naval vessels. The army transport "Sumner" has also a 10,000-gallon or 50-ton machine, which was built by me.

Very truly yours, M. T. Davidson.

43 Keap St., Brooklyn, March 30, 1900.

A Method of Making a Farm Survey.

Sir: I have been much interested in reading the article "A Method of Making a Farm Survey," by Mr. G. B. Zahniser, in your issue of this date. The detail as worked out by Mr. Zahniser strikes me as excellent. It may interest Mr. Zahniser and others to know that this same general method is found described in Raymond's "Plane Surveying," as is also the detail of the systematic office work. I believe also that Mr. Zahniser will find Crockett's tables, published separately, or with Crockett's Trigonometry, or with the text-book of surveying mentioned, fully equal to Gauss for rapidity of work.

Troy, N. Y., March 29, 1900. W. G. R.

The Rusting of Steel Nails.

Sir: Have you had your attention called to difficulties from the rusting of steel nails used for outside work? In this vicinity steel nails—both wire and cut—have been largely used in recent years, especially for shingling. Experience shows that these steel nails quickly rust off close to the boarding; the shingles blow off; and, in from three to nine years, the buildings have to be reshingled, although the shingles themselves are worn scarcely at all. Wrought-iron nails driven 60 years ago in outside work are still in a good state of preservation. There seems to be no doubt, therefore, that the steel is not nearly as durable, when exposed to the weather in this climate, as is wrought iron. I would like to know if the same experience has been had in other parts of the country? Or, is the damp, foggy climate of the Maine coast responsible for the rapid corrosion of the steel nails? Yours truly,

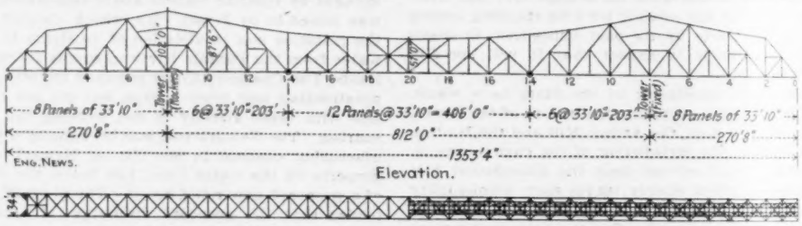
Macy S. Pope.

East Machias, Me., March 28, 1900.

(The very rapid corrosion of the steel nails is doubtless due to the climate; but the fact that steel corrodes more rapidly than wrought iron in any locality is now pretty well known. As some difficulty would probably be found in procuring nails made from wrought iron, the use of copper nails for shingling would perhaps be the most available remedy.—Ed.)

A Proposed Design for a Long-Span Cantilever Bridge.

Sir: The accompanying sketch shows one of several proposed designs made by me last summer for a cantilever bridge. I should be pleased if some of your readers would express an opinion in reference to the practicability and advisability of such a design for a long span and also for a short span cantilever bridge. The bridge would be fixed on the east tower and rest on the rollers on the west tower. It would be erected by setting the west half on the rollers nearer the shore than its final position, and making the center connection by pulling the parts together with turnbuckles. The top chords from 12 to 16 are adjustable and are fitted to take tension, but not compression, and after erection will take tension only when one panel point 14 sinks more than a certain amount below the corresponding panel point at the other end of the suspended span. The rollers would be similar to those designed by Mr. Geo. S. Morison for the middle pier of the Memphis bridge check bars being used to prevent any accident to the rollers. The method of making the center connection is simple, and the continuous floor system makes the bridge stiff laterally.



PROPOSED DESIGN FOR A LONG SPAN CANTILEVER BRIDGE.

The adjustable members of the top chord, if considered advisable, can be so arranged as to increase the vertical stiffness of the bridge by reducing the deflections at the ends of the suspended span, the frequency and amount of these deflections being one of the objections to a cantilever bridge. The suspended span and the adjustable top chords can be so arranged that, in case of excessive deflection occasioned by the injury of one of the members of the suspended span, the bridge could act as a cantilever all the way from each tower to the injured member. This method of erection is similar to the method used for the erection of the Northfield bridge over the Connecticut River, as described in Engineering News, Sept. 7, 1899. The Northfield bridge was a lighter bridge, but was loaded with about 340 tons of sand and was connected in about 2½ hours without any trouble whatever. From my experience on that bridge I should myself consider this design and this method of erection to be good. Very truly, J. Carrier.

147 West 21st St., New York, N. Y., March 12, 1900.

Checking Multiplication and Division by Casting Out the 11's.

Sir: A method of casting out the 11's by which each and every step of the operation may be very easily checked may be interesting to some of your readers as it avoids the practical necessity of waiting for the entire completion of the computation. The fundamental principle is very important, and is easily demonstrated mathematically, but I will not occupy space by doing so, as it will be much clearer by an example, especially when we come to the application.

	5	49	78	96	8
			49	32	4
	10	99	57	92	5
1	64	93	68	8	9
49	48	10	64		6
2	19	91	58	4	1
2	71	15	62	30	72	21= 11+10

Fig. 1.

Let the remainder left after casting out the 11's out of any number be called the E of that number. Then the E of 5,497,896 is also the E of the sum of the numbers 5, 49, 78 and 96. The work will be much shortened if we find E of each of these component members separately; thus, 5 + 5 + 1 + 8 = 19 = 11 + 8. Hence 8 is the E of 5,497,896. The operation of multiplying 5,497,896 by 4,902 is shown in Fig. 1. The operation of checking is conducted as follows, the E's being set off on the right: 2 × 8 = 16 = 11 + 5, and 5 is the E of 10,995,792. The E of 30 is 8, and 8 × 8 = 64 = 55 + 9, and 9 is the E of 164,936,880. (We add a cipher because the last figure on the right is to the right of the vertical line.) Again, 9 × 8 = 72 = 66 + 6, and 6 is the E of 49,481,064. The E of 40 is 7, and 7 × 8 = 56 = 55 + 1, and 1 is the E of 219,915,840.

The detailed process of checking the division of 5,497,896 by 163, giving a quotient of 33,729 and a remainder of 69, is shown in Fig. 2. The numbers written above the quotient are explained as follows, viz.: 3 is the E of 3; 0 is the E of 330; 7 is the E of 337; 5 is the E of 33,720; 3 is the E of 33,729. The remaining figures are explained as follows: 9 is the E of 163 and is written above it. The figures written in the vertical column, viz., 8, 5, 3, 6, etc., are the E's of the numbers to the right of them. Now proceed to check. 3 (above the 3 in the quotient) × 9 = 27 = 22 + 5, and 5 is the E of 489, and 8 − 5 = 3, and the latter is the E of 607,896. The E of 30 (in 37 in the quotient) is 8, and 8 × 9 = 72 = 66 + 6, and 6 is the E of

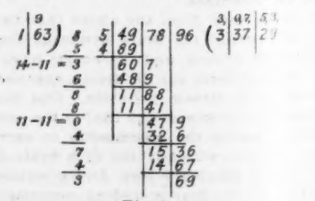


Fig. 2.

4,890. 3 + 11 = 14, and 14 − 6 = 8, which is the E of 118,896. To prove this, take the figure 0 above the quotient; then 0 × 9 = 0, and 8 − 0 = 8. Again, 7 (in the quotient) × 9 = 63 = 55 + 8, and 8 is the E of 1,141, and 8 − 8 = 0, which is the E of 4,796. To prove this, 7 (above the quotient) × 9 = 63 = 55 + 8, and 8 − 8 = 0. Again the E of 20 (in 29) is 9, and 9 × 9 = 81 =

77 + 4, and 4 is the E of 3,260; 11 + 0 = 11, and 11 − 4 = 7, and the latter is the E of 1,536. To prove this, 5 (above the quotient) × 9 = 45 = 44 + 1, and 8 − 1 = 7. Again, 8 (in the quotient) × 9 = 81 = 77 + 4 and 4 is the E of 3,697, and 7 − 4 = 3. To prove this, and also give the final check, 3 (above the quotient) × 9 = 27 = 22 + 5, and 8 − 5 = 3. It will be noticed that figures to the right of a vertical line are considered, for the purpose of finding the E, as occupying the tens place, and those on the left the units place.

Fig. 3 shows the method of procedure when the vertical lines cut off only one figure on the extreme right of the first partial product (5,088 in this case) and consists

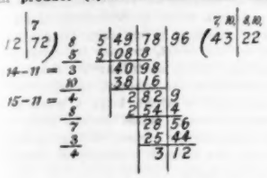


Fig. 3.

merely in cutting off the first two figures on the extreme left of the quotient instead of one as in the previous example. In order to prevent any possible confusion of figures it may be necessary to explain that this figure (Fig. 3) is the division of 5,497,896 by 1,272 giving a quotient of 4,322 and remainder of 312. No other explanation is necessary as the rest of the procedure is the same as Fig. 2.

The method may be applied also to the extraction of the square or cube root and every step checked; but it is hardly necessary to give detailed explanations here. I have found it very convenient in my own practice, especially where great accuracy is required, and more soothing than a headache powder. The figures representing the E's should be writen, either with different colored ink, or a pencil of different hardness or softness from the writing tools with which the calculation is performed.

Yours truly, C. H. Lindenberger.

89 Park Ave., Detroit, Mich., March 14, 1900.

A Method for Checking Addition.

Sir: The writer makes no claims to originality for the following method for checking addition, but, as he has found it to be simple and reliable, he thinks it may be of some value to your readers.

Having found the sum of a column of figures it is desired to check the addition.

Beginning from the right hand side add crossways the alternate digits of the columns, as a b c d e, etc.; from this sum subtract the sum of the remaining alternate figures, as f g h i, etc. If the second sum is greater than the first, increase the first sum by enough elevens to make the first sum greater than the second. Subtract the second sum from the first and place the differences thus found in a column for addition. Add these differences and subtract the sum of the second alternate from the sum of the first alternate figures, increasing if necessary the sum of the first alternate figures by sufficient elevens to make said sum greater than the sum of the second alternate figures. The difference thus found is equal to the difference found by subtracting the sum of the second alternate figures from the sum of the first alternate figures (increasing the sum if necessary by sufficient number of elevens) of the answer of the column of figures, and gives the desired check:

e	l	d	h	c	g	b	f	a		R
7	6	5	4	3	2	1	2	5	21 − 14 =	7
8	0	2	4	6	8	0	4	8	24 − 16 =	8
5	6	9	2	5	8	1	4	7	25 − 20 =	5
4	8	2	8	0	9	8	9	6	20 + (2 × 11) = 42, − 34 =	8
3	6	9	2	5	8	1	4	7	25 − 20 =	5
2	9	6	8	0	9	4	6	8	20 + (2 × 11) = 42, − 32 =	10
5	9	6	9	1	8	6	5	3	21 + 11 = 32, − 31 =	1
6	2	8	4	0	6	3	1	7	24 − 13 =	11
7	3	9	5	1	7	3	9	5	25 − 24 =	1
8	1	4	7	0	7	4	1	8	24 − 16 =	8
9	2	3	5	7	9	1	3	5	25 − 19 =	6
4	1	8	5	2	9	6	3	0	20 − 18 =	2
	9	0	8	0	8	0	9	0	(11 × 4) = 44, − 34 =	10
7	2	9	8	5	0	2	4	6	9	23 + 11 = 34, − 29 = 5	82

2 + 11 = 13, − 8 = 5 }
23 + 11 = 34, − 29 = 5 } check.

Warren R. Borst.

191 Hamilton St., Albany, N. Y.

(For the delectation of those of our readers who have the time and inclination to trifle with such matters, we append the following proof of the above method:

Let,

N = a number,

d_0, d_1, d_2, etc., = its digits,

D = the difference between the even and odd digits, and

R = radix of the system of numeration used (= 10 in the ordinary system);

then,

$$N = d_0 + d_1 r + d_2 r^2 + d_3 r^3 + d_4 r^4 + \ldots$$

$$D = d_0 - d_1 + d_2 - d_3 + \ldots$$

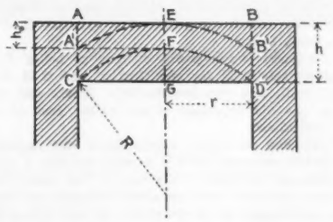
$$N - D = d_1 (r + 1) + d_2 (r^2 - 1) + d_3 (r^3 + 1) + \ldots;$$

therefore, N − D is divisible by r + 1, and, if D is divisible by r + 1, so, also, is N. If D is not so divisible, the remainder from its division will equal the remainder from the division of N as long as D is positive. It is a negative, and is subtracted from r + 1, or the multiple of r + 1 numerically next greater than D, the remainder will equal that arising from the division of N. We see, then, that the quantities in column R represent the remainders from the division of the respective numbers in the column to be added. In this connection the remainder 11 given might as well have been omitted. Now, the sum of the large column may be considered to consist of some number of elevens plus a remainder equal to the sum of column R. The latter two quantities mentioned should, of course, exceed a multiple of eleven by the same amount, which furnishes the desired check. This method obviously fails when an error is made of a whole eleven. For our part we do not see that the method is shorter, and is certainly far from being as simple as the ordinary method of adding the column in reversed order, which furnishes a very certain check.

A proof similar to the above may be applied to the method for checking multiplication by casting out the elevens, given by Mr. Lindenberger; but here again we may remark that, the slide rule, the use of logarithms, or even the repetition of the process with the multiplier and multiplicand transposed, seem to us more practical and convenient methods for the busy computor.—Ed.)

Stresses in Circular Plates.

Sir: I have read with much interest the discussion on stresses in circular plates between Mr. Edward Godfrey and Professors Lanza and Church, in your issue of March 8, and beg a little space to show a method I employed about four years ago to find a rational formula by which I could compute with safety the thickness of circular plates fixed all around, uniformly loaded, a problem which I had to solve in designing d'Auria pumping engines.



Let A B D C be a flat circular plate of thickness h and radius r, fixed all around. With any radius R describe a spherical segment C F D, so that the point F is below the point E of the plate, and with the thickness E F = h_0 describe the spherical segment A' E B' D F C. Putting $F G = \frac{h}{n}$, and denoting by f the working strength per unit area, and by p the load per sq. in., we get

$$h_0 = \frac{n-1}{n} h = \frac{R p}{2 f}. \qquad (1)$$

The value of R is given by

$$R^2 = r^2 + \left[R - \frac{h}{n}\right]^2,$$

from which we get

$$R = \frac{h^2 + n^2 r^2}{2 h n}. \qquad (2)$$

In order to get out of the flat plate the spherical segment of greatest strength we have to make

$$\frac{2 \pi R h_0 f}{\pi R^2 p} = \text{maximum},$$

or,

$$\frac{h_0}{R} = \frac{n-1}{h^2 + n^2 r^2} = \text{maximum},$$

which gives

$$n = 1 + \sqrt{1 + \frac{h^2}{r^2}}.$$

Substituting this value in (1) and (2), and solving for p, we get

$$p = \frac{2 f h^2}{r^2 + r^2 \sqrt{1 + \frac{h^2}{r^2}}}.$$

Neglecting $\frac{h^2}{r^2}$, we can write approximately

$$p = \frac{f h^2}{r^2}; \qquad (3)$$

or,

$$h = r \sqrt{\frac{p}{f}}; \qquad (4)$$

and also $h_0 = \frac{1}{2} h$.

The additional strength contributed by the metal left above and below the spherical segment of thickness h_0, is practically equivalent to that of a flat plate of thickness $h_1 = \frac{1}{2} h$, which plate, treated in the same manner as the original one, would give

$$p_1 = f \frac{h_1^2}{r^2} = f \frac{h^2}{4 r^2} = \frac{1}{4} p,$$

plus the strength derived from a flat plate of thickness $h_2 = \frac{1}{2} h_1 = \frac{1}{4} h$. Carrying this process ad infinitum we would get

$$p_2 = f \frac{h_2^2}{r^2} = (\tfrac{1}{4})^2 p;$$

$$p_3 = f \frac{h_3^2}{r^2} = (\tfrac{1}{4})^3 p;$$

$$\ldots\ldots\ldots\ldots\ldots$$

$$p_n = f \frac{h_n^2}{r^2} = (\tfrac{1}{4})^n p.$$

Hence, the total pressure per sq. in. which the original plate can support is

$$\Sigma p = P = f \frac{h^2}{r^2} [1 + (\tfrac{1}{4}) + (\tfrac{1}{4})^2 + (\tfrac{1}{4})^3 + \ldots + (\tfrac{1}{4})^n]$$

which for n = ∞, gives

$$P = \frac{4}{3} f \frac{h^2}{r^2}, \qquad (5)$$

or

$$h = r \sqrt{\frac{3}{4} \frac{P}{f}}. \qquad (6)$$

The formula given by Professor Lanza is

$$h = r \sqrt{\frac{2}{3} \frac{P}{f}},$$

which is less than 6% below the value given by my formula.

For a circular plate, supported all around, Professor Lanza gives

$$h = r \sqrt{\frac{5}{6} \frac{P}{f}},$$

and the mean between this and the preceding value is

$$h = r \sqrt{\frac{2.25}{3} \frac{P}{f}} = r \sqrt{\frac{3}{4} \frac{P}{f}},$$

which is exactly the value given by my formula.

Sincerely yours, Luigi d'Auria.

Drexel Building, Philadelphia, Pa., March 10, 1900.

What is the Value of Extra Pressure in a Water Supply for New York City.

Sir: Having called your attention to the impropriety of contrasting, in matter of cost, an additional water supply for New York city at a pressure of 300 ft., with the present supply having a maximum pressure of 100 ft. (Eng. News, March 22, p. 194), you reply that 300 ft. pressure is no good anyway, and that New York having commenced as she did, has got to keep on with no water above the second floor in a vast territory, hardly any real water pressure downtown, none for the tall buildings, and no adequate fire protection in the dry-goods district, and that tens of thousands of pumps run uptown and downtown by private parties isn't so bad a makeshift for a public water supply for the metropolis after all. The laying of special high pressure mains in high pressure districts, for those who want and need the high pressure, is the system in use in scores of cities, and the fact that the New York high pressure districts would not themselves be on a materially higher elevation above tide than the low pressure districts, would form no objection to the plan. Of course we all know that even low pressure street mains are tested to nigh 700 ft. pressure, but then there is the plumbing in the houses. Either improved plumbing, or pressure regulators at $4 or $5 each, "20% off," for each weakly plumbed house, might be used to protect the plumbing, but perhaps you are right. There is a lot to be said in favor of the old way, even if it is stupid and an imperfect one, and it is, at all events, much easier to keep on following it.

You also demonstrate that contracts could be let to give forever the water now supplied to New York city 200 ft. more pressure, for from $4 to $7 per million gallons. Perhaps so, though I think $10 would be nearer the mark, when all sorts of fixed charges are included, besides mere operation; provided the contractor had the water within the city limits to elevate. But has he? Or has the city? More than that: where can anyone go to repeat the comparatively simple and inexpensive operation of bringing in the water of the Croton River? Having got the comparison from: as $36 is to $70, up to: as

$46 is to $70, this additional trouble to overcome, of finding the new water, and of bringing it to the pumps located within the city, to be pumped, will give another lift to the first factor in the comparison. Nor should there be anything strange about that. Official documents show that the water furnished Brooklyn costs an average of $65 per million gallons, and those works reach out over but a small extent of territory. What a fair price would be, at which New York city might contract to buy water delivered by the million gallons, your correspondent is not at present prepared to say. But he does say that these various spasms of civic indignation at the fear of being robbed, should have argument to support them. Otherwise they degenerate into hysterics, and cause the metropolis to cease from being the proud exemplar, which we all know her to be in so many things, to the "hinter-land," the rural districts, and to other cities and towns.

The editorial corps of Engineering News, it is well known, believes in the municipal ownership and construction of water-works. It argues for them at all times. That is all right. Opinions on statecraft are open to all. But your present correspondent submits that this does not authorize technical items to trim sail so as to join mere hues and cries.

A serious examination of the subject will show that $70 per million gallons delivered at an elevation of 300 ft. above tide, cannot be far out of the way for additional water thus delivered to New York city. Government work always costs much more than work done under the spur of private enterprise. It also gives ample opportunity for wholesale robbery of the people under an imperfect form of government. So that it is altogether probable that New York city cannot by municipal undertaking bring in a new 300-ft. pressure water supply for so little as $70 per million gallons. All of which goes to prove that a good deal may be said in commentary of a bald comparison in figures between the price of Croton water as now delivered and an offered price to deliver additional water to New York city at an elevation of 300 ft. above tide.

Faithfully yours, H.

New York, March 28, 1900.

(We are inclined to stick to our figure of $4 to $7 as that at which contracts could be let to add 200 ft. head to New York's water supply. The figures of Mr. Artingstall did not, it is true, include interest and depreciation on the cost of the plant. On the other hand, they did include the records of a lot of more or less inefficient machinery; and as the highest figure named, $7, would amount to $70 per HP. per annum, we believe that plenty of contractors could be found who would undertake to do the work at that figure.

If our correspondent criticises the comparison of the cost of the Croton supply with the cost of the proposed Ramapo supply, we freely admit that any such comparison must from the nature of things be only a "rough and ready" one, and can form only a crude basis for estimating the cost of a new supply. The Croton is nearer at hand than any other drainage area, as our correspondent suggests. On the other hand, there has been a good bit of advancement in engineering matters since the two Croton aqueducts were built. Steel pipe lines could convey an additional supply at a fraction of the cost of the tunnel, for example. In an area less thickly settled, land damages and expenditures for sanitary protection might be less. Brooklyn's extensive driven well system is hardly a criterion by which to judge the cost of developing a supply from natural water courses.

We freely admit that government work generally costs more than "work done under the spur of private enterprise"; but the private corporations which exploit municipal franchises at the present day do not come under the head of "private enterprise." The same red tape, favoritism, bad financiering, inefficient management, and other well-known evils, that hamper and make expensive government work, are also to be found in many of these corporations. In addition, there must be paid to the capital invested in these corporations a large sum in the way of profits, so that when the taxpayers finally foot the bills they find that the plan of turning over such a natural monopoly as a public water supply to a private corporation is in the long run more expensive than carrying it on as a municipal enterprise.—Ed.)

An Important Decision Upon a Mill Owner's Suit to Collect Damages for Diversion of Water.

Sir: I enclose a decision recently handed down by the New Jersey Court of Errors and Appeals, in suits for water diversion brought against the Town of Newton, N. J., by certain mill owners. In 1894 the town of Newton began the construction of a system to take water from Morris Lake, one of the sources of the Wallkill River, and some eight miles distant from the town. The plans prepared by and carried out under direction of the writer included the erection of a masonry dam at the outlet of the lake, raising the water level some 5 ft. or more higher than had ever been done before, or even contemplated, and diverting to the upper portion of the lake instead of the lower, as formerly, a small stream (Pine Brook), also a feeder of the Wallkill.

A certain mill owner, some 1½ miles down the stream, had for about forty years enjoyed unrestricted use of the lakes and Pine Brook, diverting the latter at will and storing or letting down the waters from the former in such quantity and at such times as he chose. None of his arrangements, however, had ever provided for the saving of more than a trifle of the storm flows, nor were such flows conserved at all further down stream. The new work by the town enabled storing from storm flows (which formerly went to waste) fully double the quantity of water that Newton could draw through its main per year.

Arrangement was made with the before-mentioned mill owner, to continue his use of the lake for storage, allowing him unrestricted operation of the gates, so that the resulting arrangement gave him as much water as he formerly used in wet times, and more in dry times, actually a benefit to him, and without expense, besides having substantial structures, instead of dilapidated ones, to depend upon; of course, the mill owners farther down stream shared in the advantage, yet also without expense.

However, there has actually been a diversion of water for Newton's use (and Newton's wastes flow to another watershed, so that sewage does not compensate), of which technically, therefore, the mills are deprived. An English act of Parliament has long since recognized the justice of allowing compensation in kind, and where no real damage ensues, not permitting any theoretical claims to prevail. Our courts, however, have not yet risen above precedent, and still adhere closely to the letter of the old English law.

The Sparks Manufacturing Co. (paper manufacturers) and W. H. Ingersoll (grist mill), riparian owners, down stream, brought suit for damages, and the cases were very fully argued before Vice-Chancellor Pitney, many witnesses being called, both professional and laymen, and much time taken in accumulating evidence and the preparation of an opinion. The decision was adverse to the town and the award, compared even with the theoretical damage done, heavy.

The continuous horse-power claimed as being diverted was respectively 2.65 for the Sparks' and 2.54 for the Ingersoll mill, and the awards were $3,302 and $2,650, being on the old principle of equivalent cost of steam power, capitalized.

The town had purchased Morris Lake and various adjoining lands, claiming that it became thereby a riparian owner, and so entitled to the use of the water for its inhabitants, and also that no actual damage was done to any mill as a result of its operations; in fact, actual benefit being accomplished, therefore in equity, no suits should hold.

The lower court decided otherwise, and the Court of Errors and Appeals has upheld the legal points, but reversed the award, declaring against the method of making the same, and stating that the difference in market value before and after diversion is the much fairer method of estimating damages; therefore states and orders that $750 and $500 respectively to Sparks and Ingersoll shall be considered as ample remuneration.

The opinion itself, given by Justice Dixon, is very clear and thorough, and comes nearer than any previously rendered to recognizing common sense rather than technicalities.

The writer still claims, however, that in strict justice, in absence of material damage done, there should have been no award at all, and believes that the law will one day endorse such a principle in this class of cases, as well as in any other.

Yours very truly,

Louis L. Tribus.

84 Warren St., New York City, March 21, 1900.

(The decision in question is so suggestive that it is printed below. An interesting paper on "Compensating Reservoirs for Gravity Water Supplies in Lieu of Compensation for Riparian Rights and Its Legal Aspects" was read before the American Water-Works Association in 1898 by Mr. S. E. Babcock, of Little Falls, N. Y. Quite a full discussion ensued, bringing out the tendencies of court decisions in New York, Pennsylvania and Minnesota. The paper and discussion are given in full in the Proceedings of the Association for 1898, and are given in abstract in our issue of June 23, 1898. The subj[ect] was also briefly presented before the same as[sociation] in 1894 by Mr. P. D. Wanner, of R[eading], Pa. Judge Dixon's opinion in the Newton [case] was as follows;—Ed.)

N. J. Court of Err. & App., Nov. Ter[m], 1899. The Sparks Manufacturing Co., Resp. vs. The [Town] of New. ton, Appnt.; Worthington H. Ingersoll, [Resp.] vs. The Town of Newton, Appnt.

(1) When a riparian proprietor seeks the [aid] of a court of equity to restrain the diversion of water [by a] municipal corporation for public purposes, and offers [to for]ego his right to an injunction on recovering just [com]pensation, which he asks the court to determine, and [the] defendant in its answer consents to pay such compen[sation] so to be determined by the court, in case the court [considers the] complainant entitled to an injunction, the c[ourt has] jurisdiction to ascertain the amount of such c[ompen]sation.

(2) A municipality which buys a piece of land on a private stream several miles distant from [its] corporate limits, does not thereby become entitled as ri[parian owner] to draw from the stream a supply of wate[r for the in]habitants of the town.

(3) The Town of Newton has no authority to divert water from private streams, to the detriment of lower riparian owners on condition that it will store storm water and give it out into the streams in dry times, and thus confer a compensatory benefit on those owners, they not consenting thereto.

(4) In ascertaining just compensation for the diversion of water from a mill, the difference between the market value of the mill before the diversion, and its market value afterwards, is usually a simpler and safer criterion, than estimates of the probable cost of producing by steam at the mill the power which the diverted water would supply, and then estimates of the probable value of the water power at the mill, based on the rental value of power at other places more or less distant and dissimilar.

Messrs. W. H. and C. L. Corbin for complainants, respondents; Mr. Thomas Kays for defendant, appellant.

The opinion of the court was delivered by Dixon, J.:

The circumstances of these cases are very fully stated in the preface and opinion of Vice-Chancellor Pitney, 57 N. J. Eq. 367. With the conclusion there expressed touching the power and duty of the court on the pleadings and evidence, to fix the compensation that the defendant ought to pay to the complainant as a condition of withholding the injunctions to which they otherwise would be entitled, this court agrees. Only with respect to the amount awarded do we find reason for dissent.

The right to be obtained by the defendant under these decrees is the right to abstract from one of the tributaries of the Wallkill River a definite quantity of water which in its natural course would flow past the complainant's mills. The opinion of the Vice-Chancellor deals with the right to divert 800,000 gallons per day, and this quantity of water is shown by him to be capable of producing 2.54 continuous HP. at the Sparks Co.'s mill, and 2.65 continuous HP. at Ingersoll's mill. On this basis the learned Vice-Chancellor proceeds with two calculations: (1) To ascertain the probable annual cost of producing the same power by steam at these mill sites, and (2) to ascertain the probable annual value of the power at those localities, in view of the rental price of such power in other places more or less distant and dissimilar. Having thus formed an estimate of the annual value of the power, he compounds that value at 4% for 40 years, and finds the present value to be $3,302 at the Sparks mill, and $2,650 at the Ingersoll mill, and therefore awards these sums.

In this course of reasoning little, if any, attention was paid to the actual market value of the mill sites; and yet in Packard v. Bergen Neck R. R. Co., 25 Vroom, 553, this court declared that, when only part of a person's property is taken, just compensation will be made by awarding the difference between the market value of the property before any part was taken and the market value of the property after the taking.

While it may be proper in such cases as the present to take into consideration the matters on which the Vice-Chancellor's award rests, still we deem the difference between market values a simpler and safer criterion; and when it appears that by following other guides a result is reached utterly irreconcilable with this criterion, that result cannot be sustained. That such incompatibility exists in the cases before us will be made manifest by a few considerations now to be stated.

The testimony of witnesses living in the neighborhood of the Ingersoll mill and familiar with it for many years is to the effect that the fair market value of the whole plant in 1896, when these bills of complaint were filed, was $5,000 or $6,000. It has a total capacity to use 122 HP. of water, which will be furnished by about 1,100,000,000 gallons of water per month. A tabulated statement of the natural flow of the river at Ingersoll's mill, known in the case as Vermeule's Table D, which appears to have been accepted as trustworthy by all parties at the trial, shows that during eight months of the average year there is more than a sufficient supply of water for the full capacity of the mill, that during June and September the

supply is above five-sixths of the capacity, and that during July and August the supply exceeds five-ninths of the capacity. These data indicate an annual supply equivalent to 118 continuous HP., at this mill.

Now, if for the abstraction of 2.65 continuous HP., the mill owner ought to be paid $2,650, then, for the abstraction of the whole power he ought to be paid $118,000. Such an inference proves the extravagance of the award.

In April, 1898, the plant of the Sparks Manufacturing Co. was purchased by that company for $75,000. The plant includes the water machinery with a total capacity of 170 HP., steam machinery having 100 HP., mill buildings and several acres of land.

To run the water plant to its full capacity the company required about 1,360,000,000 gallons of water per month, and besides it used about 30,000,000 gallons per month for condensing steam, washing fabrics, etc. Vermeule's Table D shows that during eight months of the average year there is more than a sufficient supply of water for the full capacity of the water power, that during June and September the supply is about two-thirds of the capacity, and that during July and August the supply is about four-ninths of the capacity. These data indicate an annual supply equivalent to 141 continuous HP. at this mill.

If for the abstraction of 2.54 continuous HP. of water the company ought to be paid $3,302, then for the abstraction of the whole power it ought to be paid $183,300. This inference proves the extravagance of the Sparks Co.'s award.

We think there is another error in the basis on which the present awards are made. Assuming that the defendant withdraws 800,000 gallons of water per day (i. e., 25,000,000 gallons per month), Vermeule's Table D shows that in an average year after the allowance to the defendant is taken, more water will flow past these mills during eight months than either of the mills can utilize; so that only during four months will the supply available in the mills be perceptibly diminished. During those months the water diverted by the town would furnish 3 HP. at the mills, and 3 HP. for four months would be equivalent to 1 continuous HP. Thus, even on the assumption that water power at these mills is as valuable as the learned Vice-Chancellor deemed it to be, allowances for 2.54 and 2.65 continuous HP. are about 2½ times too large.

In our judgment an award of $500 to Mr. Ingersoll and of $750 to the Sparks Manufacturing Co. will afford ample compensation to them for the abstraction by the defendant of 800,000 gallons of water per day. Under the election by the town to abstract 1,250,000 gallons per day, these sums must be proportionately increased.

Let the present decrees be reversed and decrees be rendered in accordance with the judgment above stated.

NEW WHEEL-PIT OF THE NIAGARA FALLS POWER CO.'S POWER PLANT AT NIAGARA FALLS, N. Y.

By O. E. Dunlap.*

The present prospects are that early in 1901 Niagara Falls will have in operation another large addition to its power plants. The Niagara Falls Power Co. has awarded the contract for the construction of a second big wheel-pit to the National Contracting Co., of New York, which has been at work on its contract for some months, and has already made good progress in excavating the pit. The National Contracting Co. has appointed Mr. Walter McCulloh, of Niagara Falls, as its resident engineer, and it is under his supervision that the new wheel-pit work is being carried on. Considerable material is on the ground, and all the temporary buildings are up. A large force of men is engaged, and from this time on the work, it is expected, will progress rapidly.

The location of the new wheel-pit is on the east side of the inlet canal, opposite the present pit, but it is closer to the river shore than the present pit. When the inlet canal was built it was designed to supply water enough to operate the wheels in two pits, or enough to develop over 100,000 HP. The installation in the present pit consists of ten units, each of 5,000 HP. In the new pit there will be placed eleven units of 5,000 HP. each, making the output capacity of the new wheel-pit 55,000 HP., which, added to the installation in the old pit, will give the Niagara Falls Power Co. a total of 105,000 HP. at its command from the two wheel-pits and stations. It has been intimated that the Niagara Falls Power Co. contemplate making certain changes in the turbines to be installed in the new pit, and only recently Dr. Coleman Sellers and Mr. William A. Brackenridge, the engineers of the company, have returned from Switzerland where they went to lay the details of these changes before the engineers who designed the turbines in use in the present pit. While it is understood that the Swiss engineers approved of the ideas laid before them by Messrs. Sellers and Brackenridge, the details of the changes to be made are not yet fully perfected, and, therefore, are not made public.

The new wheel-pit will be just what the old pit is—a great slot cut out of solid limestone rock. The length of the pit between channeling machine cuts will be 463 ft. 1 in. It will have an approximate depth of 180 ft., and the width between the brick walls below the turbine deck will be 16 ft., and above the turbine deck the width will be 17 ft. 4 ins. The distance from face to face of the arris lines of masonry above the thrust deck will be 21 ft. The walls will be slightly battered. The sides will be channelled. The pit is to be lined with brick throughout. All the lower part will be lined as soon as it is ready, and the upper part will be lined as fast as the units are installed. Six of the units will be placed as soon as the pit is ready for them, and the others will be placed as fast as found necessary. The brick wall, or lining, will have a thickness of 16 ins. at the top of the turbine deck, and it will be 12 ins. thick at the top of the pit. In the construction of this lining every facility for draining the rear of the walls will be provided. On the site of the pit, about 60 ft. below the surface, there is a water-bearing strata which allows quite a large flow of water back of the walls. To carry off this and other water the inner course of brick in the lining will be hollow. Weep holes will be provided behind the walls and the seepage will be conducted to a point below the turbine deck. A method very similar was adopted to drain the walls of the present pit, and time has shown that these walls are kept very dry at all times.

The excavation of the pit has reached a depth of about 50 feet. Dynamite is used for blasting, but in such quantities that the shock of the blasts will not disturb the installations in the present pit and station. The rock is removed in benches having an approximate depth of 6 ft., and carried through at a uniform grade. The drills are operated by compressed air, a compressor station having been established near the pit. In this compressor station there are ten 100-HP. boilers and four Ingersoll-Sergeant straight line compressors, known as Class A. There will also be a 15-HP. dynamo, operated by a small engine, for lighting purposes. The exhaust of the four compressors is passed through a Stewart feed-water heater. Double expansion pumps are connected to a tubular boiler receiver 72 ins. × 16 ft. From this a 10-in. air main runs to a point opposite the center of the pit, where a second tubular boiler receiver, 60 ins. × 16 ft., is placed. Here the second expansion of air is obtained, dropping all moisture and giving dry air. Five 4-in. mains extend down into the pit 90 ft. apart.

All of the excavated material is raised out of the pit in iron buckets and is loaded onto dump cars, which are run on a track laid close to the edge of the pit. The loaded cars are run to various points about the lands of the Niagara Falls Power Co., and the material is used for filling in low places. When the original pit and tunnel were built the excavated material was used for filling in lands under water and many valuable acres of land were so redeemed. In fact, some of the great Niagara factories to-day occupy sites on land thus made. The material is also being used for solidifying the bed of the Niagara Junction Ry., the terminal line that runs over the lands of the Niagara Falls Power Co.

VIEW OF NIAGARA FALLS POWER CO.'S PLANT, SHOWING LOCATION OF NEW WHEEL PIT IN RELATION TO PRESENT POWER HOUSE AND WHEEL PIT.
Wm. A. Brackenridge, Niagara Falls, N. Y., Resident Engineer.
National Contracting Co., New York, N. Y., Contractors.

Between the new and the old pits there will be built a cross connecting tunnel 6 × 8 ft. in size, which will extend under the inlet canal at a depth of 130 ft. from the surface. It will be lined with brick, and is intended to afford passage for employees from pit to pit. It will connect the north side of the new pit to the south side of the old pit.

In order that the bank of the inlet canal may be removed in front of the new pit for the construction of the inlets and other necessary work, a cofferdam 550 ft. long is being built in the inlet canal in front of the new pit. This cofferdam is designed to keep the water back. It will be built of two cribs filled between with puddle. The outer crib will have a width of 10 ft., and the inner crib will be 8 ft. wide. The puddle will also have a width of 8 ft., and will be placed between sheeting driven on the inside of the cribs. The cribs will be filled with stone. In front of the stone bridge that connects the present power house with the transformer station a similar cofferdam 120 ft. long has been built to keep the water out of the inlet canal to the east of the bridge mentioned. In this section of the inlet canal, which is thus kept dry, in front of the power house, a shaft 10 by 16 ft. wide and long is being sunk. It will have a depth of about 180 ft. to the bottom of the tunnel, over the heading of which it is being sunk. This shaft is intended to aid in the extension of the tunnel from its present point of ending around to the new wheel-pit.

In extending the tunnel its present horseshoe section will be adhered to, which is 18 ft. 10 ins. wide at the widest part, and a little over 21 ft. high. The present length of the completed por-

*Niagara Falls, N. Y.

tion of the tunnel is 6,820 ft., and the extension will be 616.5 ft. long, making the total length to be 7,436.5 ft. This new section of the tunnel will have a curve 368½ ft. long, and the radius of the curve will be 186½ ft. It will be built on a grade of one-tenth of one per cent., and will be bricklined, the same as the present tunnel.

When the original wheel-pit and shafts were built much trouble was experienced from the inflow of water, but in the new work steps have been taken to obviate this trouble. In the bottom of the shaft above mentioned three 8-in. holes have been drilled down into the tunnel heading, and through these holes the water that flows into the shaft passes into the tunnel, thus saving the expense of pumping it out. Two 8-in. holes have also been sunk in the north end of the new pit at a point where they will be intersected by the tunnel when it extended around there.

It is probable that some changes will be made in the power house as compared with the present station, but just what these will consist of has not yet been fully determined by the Niagara Falls Power Co., the plans and details now being in preparation and under consideration. In the construction work the interests of the Niagara Falls Power Co. are looked after by Mr. William A. Brackenridge, who is the resident engineer at Niagara Falls of the company.

LEGAL DECISIONS OF INTEREST TO ENGINEERS.

Pollution of Water Course.

Riparian owners on Naugatuck River who secured a judgment for money damages and a permanent restraining order against the city of Waterbury, Conn., have just won out in the Supreme Court of Errors of that state. The decision, which covers some interesting points, may be paragraphed as follows:

The right to maintain a nuisance by polluting a river, rendering it dangerous to the public health and destructive of the value of neighboring property, cannot be acquired by prescription.

A city's discharge of sewage into a stream in such quantities as to destroy the value of property of lower riparian proprietors, and to be destructive of health, is an unreasonable use of the stream.

A city's prescriptive right to pour its surface drainage into a river does not include the right to mix therewith noxious substances which the river cannot dilute or safely carry off without injuring private property.

The right to enjoin the pollution of a river by the sewers of a city is not contingent on future action of the legislature, which has taken steps towards the adoption of a plan of sewerage for the whole river valley.

Merely granting a city authority by its charter to construct sewers to carry off the refuse of its inhabitants to a river does not make such use of the sewers a government act, freeing the city from personal liability for injuries resulting therefrom, as from the lawful exercise of a governmental power.

Where the sewage of a city polluted a stream so as to destroy the value of plaintiff's manufacturing plant located thereon, plaintiffs were entitled to maintain injunction against the city to compel it to provide other means for disposing of its sewage within ample time, or to compensate plaintiffs for the injuries sustained to their property.

Pollution of a river by city sewers so as to destroy the value of property located thereon is a taking of private property for a public use within the meaning of the constitutional requirement that just compensation shall be paid therefor; and, no matter what the necessity therefor, the city cannot avoid its liability to render just compensation therefor.

Platt et al vs. City of Waterbury, 45 At. Rep. (Conn.), 154.

WATER SUPPLY AND STORAGE.

The Connecticut Civil Engineers' and Surveyers' Association has made an innovation by holding a spring meeting this year. This is in accord with the recent activity of the society, which added very largely to its membership at the winter meeting, in January, and had a further accession of 20 members at the meeting on March 30.

The topic for consideration last Friday was "Water Supply and Storage." Messrs. Chas. E. Chandler and Geo. H. Bishop, submitted a report for the committee on water supply, in which they summarized special reports on storage and allied subjects from a number of water-works in the State. The average rainfall for some 15 stations throughout the State was 64.49 ins. in 1897, 56.43 in 1898, and 41.45 in 1899, the normal being about 48 ins. The rainfall for the first three months of 1899 was ample, but some works had insufficient storage capacity to conserve it, and, therefore, suffered a shortage before the year was over. Only one of the works reporting gave definite figures regarding the amount of water wasted through insufficient storage, and the report and discussion indicated a great lack of data on the part of the various works, regarding the actual and potentially available supplies from the several drainage areas, and also as to the consumption from gravity works. Hartford, alone, of the gravity works, appeared to have any means of determining its consumption, but even there it was possible to pass the whole supply through the Venturi meter only a few days in each month.

There was quite a spirited discussion over the relative merits of ground and surface water supplies. Most of the participants favored surface supplies, as might be expected in a section where such supplies are in the majority.

The subject of anchor ice was brought up by Mr. Wm. B. Cochrane, of Stamford, who stated the water company of that place had just been having trouble with anchor ice at the outlets from its reservoirs. A member suggested that the area of the outlet openings should be increased so as to diminish the velocity. Mr. H. A. Storrs, after referring to the use of heat from an electric coil placed about an intake to prevent trouble from needle ice, said he had used electricity to thaw frozen pipes, and that the amount of heat required to dislodge ice was surprisingly small.

An informal talk, with lantern slides, along the subject of the day, was given by Mr. Desmond FitzGerald, Past Pres. M. Am. Soc. C. E. He suggested that wells might be driven near a stream of unsatisfactory character, and their yield increased in dry weather by a cheap system of filtration, provided by stripping the surface soil from the ground near the wells, placing it in embankments, and delivering the brook water on the surface, so formed, from which it would pass to the wells, being filtered meanwhile. The greater part of the talk was devoted to a description of the reservoirs and aqueducts of the Boston and Metropolitan water supplies, which have been described in various past numbers of Engineering News.

In response to a question regarding the best point in the depth of a reservoir for drawing water, Mr. FitzGerald explained how it varied with the changing character of the water at different seasons and depths. On the Boston and Metropolitan works weekly samples for analysis are collected from the top, middle and bottom of each reservoir and the points of draft from the reservoir are varied according to the results obtained.

THE PRACTICAL APPLICATIONS OF LIQUID AIR.*

By Carl Linde.†

As it has now become possible to liquefy any desired quantity of atmospheric air by relatively simple means, the newspapers and the technical press have taken up the question of the practical uses to which this new product may be applied. Frequently in an exuberant and sometimes in a wholly ridiculous manner the range and possibilities of the application of liquid air have been by writers in these journals extended even beyond the limits of physical possibility.

Such a Utopian treatment of the subject does not deserve serious attention when it arises only from ignorance and a frivolous desire to be sensational, or is presented in extravagant advertisements. It is to be found, however, to a limited extent in publications to which neither the honesty nor the ability requisite to form a fair judgment can be denied. Indeed, from the questions which daily arise in such circles, it is evident that very erroneous ideas are prevalent concerning the limits to the use of liquid air. Since I have occupied myself much with these questions, it appears to me proper that I should here attempt to indicate these bounds as clearly as possible. My exposition, then, will be chiefly of a negative character. In its positive aspect, that is, in a description of the practical uses of liquefied air, I could bring forward nothing new, and as for statements concerning uses already proposed, I am afraid they would not agree with some expectations possibly cherished. This assemblage of scientists is a fit place to bring forward these matters, since the applications of liquid air are not confined to the industries, but extend into the domain of science and, also, that of medicine.

If air could be liquefied at no cost or with a very little expenditure, and if we possessed vessels in which it could be kept as long as we pleased, then, indeed, the field of application of liquid air would be very great. In the correct judgment and weighing of this "if" is to be sought the standard for determining that which is possible.

First, then, we must answer these two questions: (1) What expenditure of energy is demanded for the liquefaction of a given mass of air? (2) How long can a given mass of air be preserved?

For answering the first question we have to-day not only mere theoretical considerations, but also experiments which have been made with a large number of small and large machines. During the last two years nearly 50 machines for the liquefaction of air have been delivered to physical and chemical laboratories. These machines cannot yet be regarded as perfect. Manufacturers will not be surprised that the mechanical solution of a new problem requires a certain period of time. Still by the aid of the "double cycle," in which the greater mass of the air circulates between two high pressures, the smallest devices nearly one kilogram of air may be liquefied per hour with 3 HP.; in the larger machines the work required is naturally less. The largest machine as yet tried delivers 50 kilograms per hour with a little less than 100 HP., and requires, therefore, a little less than 2 HP. per kilogram. It may be that with further perfection of the liquefiers this figure can be lowered to 1.5 HP. per kilogram per hour. That it should be reduced to 1 HP., however, appears to me doubtful, although not impossible. Theoretically, this would correspond to an efficiency of about 30%. In the entropy-temperature diagram, Fig. 1, the area ABED represents the specific heat to be removed (about 50 calories per kg.), and BCFE the latent heat (about 60 calories per kg.) If the absolute temperature T_1 at which heat must be discharged to the cooling water is 273 + 20° C., and the absolute temperature of the liquefied air is 273 — 190° C., then the area ABCG which must be applied as mechanical work, represents about 190 calories, which corresponds to 0.3 HP. per hour. The present attained or surpassed performance of 1 kilogram of liquid air per 2 HP. hours corresponds to an efficiency of 15% of the theoretically perfect machine.

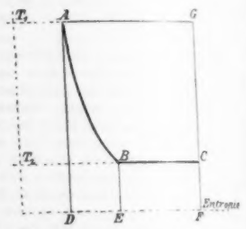


Fig. 1.—Entropy-Temperature Diagram, Showing the Work Required to Liquefy Air.

From the above considerations it may be estimated that with a large plant (1,000 kg. per day) the total cost per kilogram would be about 2½ cts. This figure might be reduced in large plants and would be higher in small ones.

Next, as to the time that liquid air may be kept. Small quantities may be preserved in well exhausted and silvered double-walled glass vessels for a relatively long time. One liter of liquid air requires for its evaporation in such a vessel about 14 days. The ordinary sheet-iron vessels used industrially, holding about 50 liters, and covered with felt or wool, allow about 2 liters to evaporate hourly. Experiments are being made with a view of building large double-walled and silvered sheet-iron holders, and we may expect that holders will be constructed in which the evaporation will be not more than 1% per hour.

If, now, in the light of the foregoing statements, we examine the prospective uses of liquid air, there are the following three cases: We may turn to account (1) the low temperature of liquid air, (2) its ability to absorb heat energy from its surroundings and to convert the same into mechanical work and (3) its separation by evaporation into oxygen and nitrogen.

The application of liquid air as a refrigerant has been the subject of much speculation. The farmer hoped to have found a simple and inexpensive means of cooling and aerating his cow-stables, and the directors of large industrial works thought to make the same application of liquid air in their shops. Countless inquiries and schemes were founded on the uses that could be made of liquid air as a refrigerant. It is unnecessary to speak further of this matter, as the fancies of journalists have done it full justice.

In connection with all these schemes no attention has been paid to the fact that refrigeration by liquid air requires an unreasonable amount of power. If, for instance, an ordinary refrigerating machine takes heat from a substance at — 7°C., and discharges it to the cooling water at 20° C., the ratio of the work required to the heat removed is, according to the well-known formula $\frac{T_2 - T_1}{T_1}$, 1:10; by liquid air, from the values before given, it would be $\frac{190}{50 + 60} = 1.7$; that is, the work theoretically demanded in the latter case is 17 times as great as in the former. If we remember further that the efficiency of the ordinary refrigerating machine is more than twice that of the liquid air machine, it is apparent that a given amount of refrigeration by liquid air requires 40 or 50 times as much work as with the ordinary machines as long as the temperature desired is not far below the freezing point of water.

It should then be insisted upon that the only appropriate applications of liquid air as a refrigerant are

*A paper read before the Society of German Naturalists and Physicians at Munich. Translated from the Zeitschrift des Vereines Deutscher Ingenieure, Jan. 20, 1900.

†Professor in the Technical School at Munich, Bavaria.

either where a degree of cold is desired much lower than that possible with ordinary refrigerating machines, such as temperatures below — 50° C., or else where the special properties of liquid air compensate for the great expenditure of work which applies in only a few instances. Examples of the first case will be found only in scientific investigations, and it is not yet evident whether or in what direction chemistry will in the future make use of such low temperatures.

In regard to the above, attention may be called to a communication by D. Campbell White in the New York "Medical Record," according to which salutary results were obtained by the application of liquid air in certain diseases, as bunions, lupus, carbuncle, etc. The great cooling produced by momentary sprays of liquid air brings about a long lasting hyperemia, which, according to a common maxim, operates to cure infectious disorders.

As an application easily made, supposing, of course, the liquid air industry to be organized like the ice industry, liquid air may be used as a refrigerant by the luxurious, as, for example, upon the dinner-table, or, having no regard to cost, we may use it to furnish cool and pure air to sick-rooms, assembly halls, etc. But in any case, as is apparent from the foregoing, the application of liquid air as a refrigerant is confined to a very narrow field.

The same may be said in regard to its use for motor purposes. Liquid air may take from the universal store of heat in our surroundings a certain quantity of potential and kinetic energy, by which its thermodynamic state will be changed, so that the product of pressure and volume (p v) will increase, which increase makes possible the doing of mechanical work by expansion. The value of p v may be further increased if the change of thermodynamic state includes also the burning of oxidizable materials. From the fact of this possibility of using liquid air for motor purposes altogether too far-reaching conclusions have been drawn, as in the other instances. We are not speaking here of the perpetual-motion machine of Tripler, the American, who so used three gallons of liquid air in his motor that with the energy thus generated he made seven more gallons; but we speak in earnest of the economical driving of power-generating machines by liquid air. Now, we have seen above that the energy required for liquefaction is theoretically nearly twice and actually about six times as great as the heat removed, and, likewise, as the energy which will be taken up from the surroundings on evaporating. If we remember, then, that in an engine only a certain part of this energy can be turned into mechanical work, it will need no further explanation to show that only a small percentage of the work required for liquefaction can be recovered in a machine driven by liquid air. It will be only in exceptional cases that this unfavorable efficiency will be outweighed by advantages in other directions, as, for example, in submarine work (torpedoes, submarine boats, diving, etc.), and possibly in subterranean work.

The case appears more favorable when the use of liquid air is made in connection with the combustion of suitable materials, such as petroleum. It is true that such a machine cannot be expected to be more efficient than an economical motor of the ordinary type, but its efficiency would be satisfactory where it was desired to take advantage of the peculiar merits of this combination. One of these merits is the possibility of making a great reduction in the weight of the machine. The construction and mode of operation of such a machine we may suppose to be something as follows: From a holder well insulated from heat and containing liquid air at atmospheric pressure a small pump would take regularly a certain amount of liquid air and inject it into a pressure system which would receive at the same time a proportional amount of petroleum, so that the oxygen of the liquid air would burn the petroleum at a pressure of, say, 50 atmospheres. The resulting gases could be used to do work by expansion in cylinders in the ordinary manner. It is apparent that the high pressure resulting from the evaporation of the liquid air here replaces the compression, which is indispensable in a good petroleum motor, and that the entire work of expansion is available, while in ordinary machines we have only the difference between the work of expansion and the work of compression. Therefore, the expansion-cylinder will be materially smaller and the compression cylinder can be entirely omitted. So, finally, when small size and light weight are more important than efficiency, and where the use of liquid air presents no difficulty, the use of the above described device may be considered, as, for example, with certain classes of motor vehicles.

In still another direction it has been proposed to utilize the motive power set free by the burning of oxidizable material in liquid air, namely, in the production of explosives. The subject had scarcely been mentioned before there were cries of "the explosive of the future," which would speedily supplant all former explosives. And yet here, from the instability of the material, the limits of its application are especially apparent. In connection with this obvious application there is brought to our attention one of the characteristics of liquid air upon which the presently-to-be-described production of gases rich in oxygen depends, namely, the phenomenon that the nitrogen evaporates more rapidly than the oxygen, so that the liquid is the richer in oxygen the longer evaporation continues. If we mix such a liquid rich in oxygen with a suitable finely divided combustible material, the mixture exhibits explosive qualities. Mineral oil which has been absorbed by infusorial earth or pulverized cork-charcoal and then saturated with liquid rich in oxygen surpasses, when the proportions of mixture are correct, all other commercial explosives in respect to the pressure and volume of the burnt gases from a given weight. It should be added, however, that the specific gravity of the mixture is only a little more than unity, which is considerably less than that of the ordinary

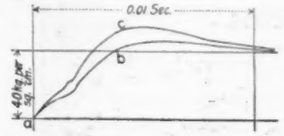


Fig. 2.—Time-Pressure Curve from Explosion of "Oxyliquit."

(40 kg. per sq. cm. = 568 lbs. per sq. in.)

explosives. Fig. 2 shows the indicator cards obtained by detonating in a steel vessel of 20 liters capacity 85 grams of explosive gelatine (curve a b) and a mixture of 17 grams of petroleum and 62 grams of a liquid of which about 80% was oxygen, with 17 grams of infusorial earth in 9 grams of paper (curve a c).

The cost of this explosive, which has received the name "oxyliquit," will be very small where it is used regularly in such quantities as to give employment to an independent liquefying plant. This is not the only limit to its use, but it must especially be remembered that the handling of oxyliquit offers peculiar difficulties arising from its instability. The mode of procedure has formerly been as follows: The cartridges containing the oxidizable material and the vessels containing the liquid air are brought separately to the place of use; the cartridges are dipped into the liquid air until they are saturated and are then placed in the drill-holes, much the same as with explosive gelatine. It is now obvious that at the moment of taking the cartridge out of the liquid evaporation begins, which becomes the greater the longer the interval between removal and detonation. This has the further bad effect that the specific weight and, with it, the explosive power are diminished. Whether it will be possible to overcome these difficulties must still remain an open question. So far, experiments (at the building of the Simplon tunnel) have led to no solution. Some of the blasts which could be set off individually in the rock gave good results, except that uniformity was not obtained, which is to be attributed to a varying composition at the moment of detonation. It appears possible, however, that by improving the insulation of the cartridge and the composition of its contents and by practice in uniform and rapid handling the safety required for blasting purposes may be attained.

The manner in which distillation takes place upon the evaporation of liquid air under atmospheric pressure is shown in Fig. 3. If N and O represent the proportions by weight of a liquid of the composition of the atmosphere, about as it is received when atmospheric air condenses on ample cold surfaces, then at the beginning of

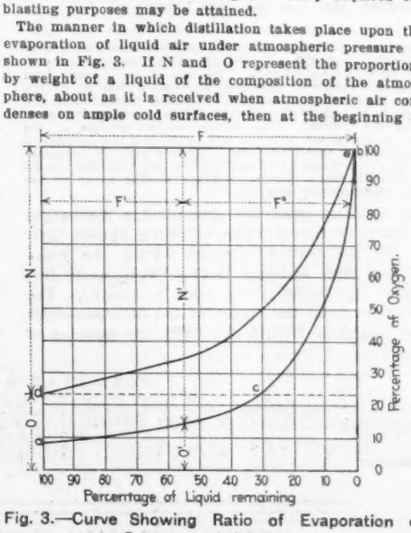


Fig. 3.—Curve Showing Ratio of Evaporation of Oxygen and Nitrogen.

evaporation the distilled product will contain about 92% nitrogen and 8% oxygen. The curve acb shows the change with continued evaporation, of the ratio of evaporated nitrogen N^1 to evaporated oxygen O^1, while the curve d e shows the progressive enrichment of the liquid in oxygen. If the evaporation takes place at a pressure lower than the atmosphere, the distillation is more rapid, while at a higher pressure it is slower.

It is apparent that if we take the evaporated gases at an early stage in the evaporation we will get a gas mixture rich in nitrogen and at a later stage, one rich in oxygen. If the process of evaporation is so carried out that the "cold" thereby released is used for the liquefaction of a similar mass of air, the only work needed would be that corresponding to the unavoidable loss of "cold"; and upon this I have founded a process of which I have stated that it offers the prospect of delivering one cubic meter per hour of gas containing 50% oxygen with 1 HP. The mechanical solution of this problem has been taken up during the current year, but many alterations must be made before it will be complete. If it succeeds in the expected manner, we may see in it the most valuable of all the applications of liquid air. From previous experiments, we may hope not only to equal the above-mentioned efficiency, but in large "air distilling plants" it will probably be exceeded. From many sides, notably by Mr. Hempel, proposals have been made in regard to this subject and the Prussian Society for the Promotion of Industry has offered a prize "for the investigation of the generator gases obtained by the use of concentrated oxygen (Linde-air)."

Mr. Hempel's proposition and the offer of this prize are based upon the assumption that one cubic meter of 50% oxygen gas can be produced for 0.3 cts., an assumption that, so far, has not been realized. Notwithstanding the provisional estimate of 0.625 ct. per cubic meter above noted for oxygen gas, there is already in sight an application of the process, according to a scheme of Mining Engineer Althans, for the manufacture of gas of high quality from low-grade coals.

Fig. 4 shows a cylindrical generator, in the upper part of which is a conical retort, which is surrounded by the gases arising from the grate, and serves to gasify the carbonaceous fuel. The "upper gases" escape separately from the "under gases," with which they can be mixed only after proper cooling. The under gases arise from the burning of the coke, sinking down from the retort in a supply of air rich in oxygen and superheated steam, and their high temperature serves to heat the retort and to produce and superheat the steam. In this manner a mixture of carbon monoxide and hydrogen with very little nitrogen can be uninterruptedly produced.

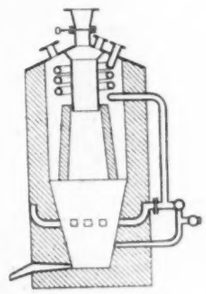


Fig. 4.—Scheme of Gas Generator to be Supplied by Air Rich in Oxygen.

In regard to other uses of gases rich in oxygen, I may refer you to the proposals of Mr. Hempel above mentioned.

If, in the preceding, the many expectations based upon the application of liquid air must be relegated to the domain of the fabulous, still there remains in prospect a wide and fertile field for the engineer and the chemist.

SEWAGE DISPOSAL BY INTERMITTENT FILTRATION AT LEICESTER, MASS.

The central village of the town of Leicester, Mass., known as the Leicester Water Supply District, completed water-works in 1891 and put a sewerage system in operation in 1896. The population of the district cannot be given, but that of the whole town was 3,120 in 1890, and 3,239 in 1895. The town is located in the drainage areas of the French and Blackstone rivers, a few miles from Worcester, with which it is connected by electric railway.

The sewers carry house wastes only, ground water being excluded by underdrains laid, apparently, beneath all laterals. The original plan provided for cast-iron pipe for a portion of the outlet sewer laid through marshy ground, but whether it was used we cannot say. To the close of 1898 there had been laid 2.14 miles of sewers, and 1.64 of underdrains. There were, on the same date, 73 sewer connections, divided as follows: Dwellings, 56; tenements, 7; factories, 5; public dwellings, 4; stables, 1.

No records of water consumption or sewage flow are kept by the district, but gagings extending throughout 24 hours were made of the flow in the outlet sewer on Aug. 16 and 17, 1898, by the State Board of Health. The flow for 24 hours was 13,600 gallons. The maximum hourly flow was at the rate of 29,400 gallons, at 11 a. m., and the minimum, 3,900 gallons, at 3 p. m. It is thought that the thorough underdrainage of the sewers excludes most of the ground water, tending to keep the flow uniform throughout the year.

The district bought 8.7 acres of land for sewage disposal purposes in 1894 and 1897, located about one-third of a mile south of the main street, a factory and a few houses being quite near by. It is

mostly on a knoll, adjoining Rawson Brook. The soil is compact, fine-grained, and contains many rounded stones. It has an effective size of 0.063 to 0.110 mm. No more suitable land was available for miles around, at least that could be reached by gravity flow.

Disposal is by means of intermittent filtration, supplemented by two trenches. The longer of the two trenches received all the sewage until the first two beds were completed, late in 1896.

The 10-in. vitrified pipe outlet sewer ends in duplicate masonry settling tanks, having a depth of about 5½ ft., and a combined capacity of 12,000 gallons. Both tanks are generally used, giving the sewage, on the basis of the one gaging made, an average stay in the tanks of nearly 24 hours. Scum boards are provided near one end of the tanks. The sludge is drained from the tanks by gravity onto a small sludge bed, say 30 × 60 ft., about once a month. Here it dries, and is then removed. In the fall of 1897, Mr. A. F. Estabrook, one of the water and sewer commissioners, stated that some of the sludge had been taken away by farmers and that it was expected they would pay for it; also that the district had used some of it to fertilize a field of oats, with good results. The State Board of Health, however, reports at a later date that the sludge is composted.

From the settling tank the sewage passes through a short surface ditch, to filter beds, or to open trenches on the hillside. At the close of 1898 there were seven filter beds in use, having a combined area of 0.35 acre, or an average area of only 0.05 each. The beds are all underdrained with 4-in. tile pipe laid about 8 ft. apart, and generally 5½ ft. below the surface. In the first two beds to be constructed the underdrains are not so deep. All the material was loosened in some of the beds, but in others the only loosening was incidental to the laying of the underdrains.

The two hillside trenches have an aggregate length of about 1,000 ft., one being 600 to 800 ft. long, and the other, of more recent construction, about 300 ft. long. The trenches are about 1½ ft. wide and 1 ft. deep, located in material about like that of the beds.

When the writer visited the disposal area, on Nov. 19, 1897, a considerable odor was noticed, but not until one was close to the beds. It was quite a cold morning, with a little snow in the air. Mr. Estabrook stated that the odor came from the trench, or the soil about it, which receives the sewage when the beds cannot take it, and becomes over-dosed. He also said that the sewage contains wastes from a shoddy leather manufactory, where soles and heels are made from leather scraps, paste and alum being used in the process. In the report of the Massachusetts State Board of Health for 1898 the following remarks are made regarding the use of the longer of the two trenches:

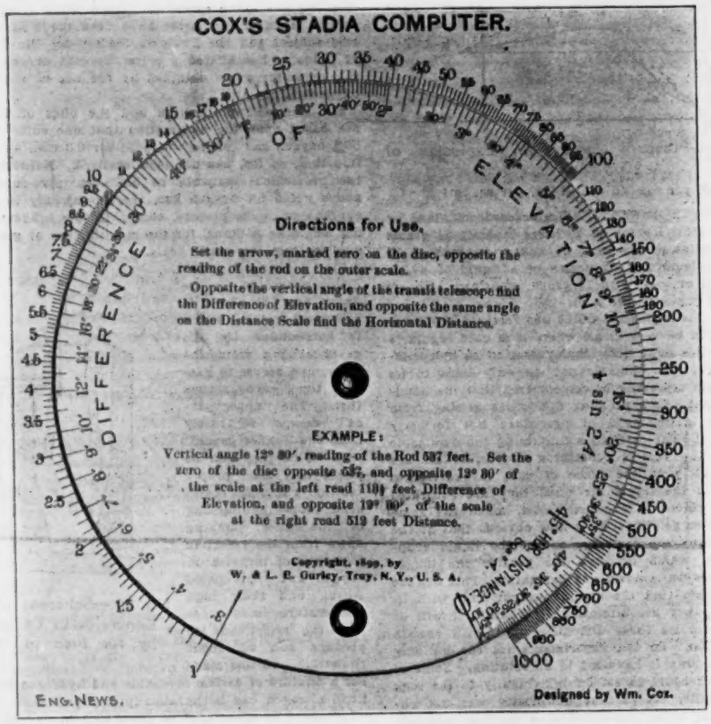
> Sewage has been applied continuously to the trench west of the filter beds for a period of several months and disposed of without difficulty. On one of the coldest days during the winter of 1898-9 it was found that all of the sewage was being discharged into this trench, and the sewage had entirely disappeared before reaching the lower end of the trench. The surface of the sewage in the trench was covered with ice and snow, but the bottom of the trench was free from frost. At this time the temperature of the sewage as it was discharged into the trench was 36.5°F., while the temperature of the water of the public water supply was 35° F.

The effluent from the underdrains discharges into Rawson Brook. The following figures indicate the purification attained during the years 1897 and 1898, analyses having "been made frequently" (probably about once a month). The figures are from the report of the Massachusetts State Board of Health for 1898, the samples of sewage being taken just before the sewage entered the settling tank, and the samples of effluent from the underdrains, just before entering the brook.

	Years	
	1897.	1898.
Chlorine: Sewage	5.59	6.18
Effluent	5.46	5.32
Free Ammonia: Sewage	2.8115	3.5642
Effluent	1.6475	1.1453
Removed	41.4%	67.9%
Total albuminoid ammonia: Sewage.	0.8418	0.8833
Effluent	0.2351	0.0841
Removed	72.1%	90.4%
Oxygen consumed: Sewage	23.14	24.30
Effluent	8.88	3.80
Removed	63.8%	84.8%

Considering the poorness of the filtering material and the fact that a high degree of purification is not demanded by local conditions, the plant seems to be giving fair satisfaction. The analyses, however, throw no light on the results obtained by the trenches. Apparently, more filter bed might be provided with advantage.

The information given herein has been drawn from recent reports of the Massachusetts State Board of Health, and from notes taken at the disposal area by a member of the editorial staff of this journal on Nov. 17, 1897. Thanks are due to Mr. Estabrook for information given on the date named. We are informed by Mr. X. H. Goodnough, Chief Engineer of the Massachusetts State Board of Health, that no further measurements of the sewage flow at Leicester have been made by the board, but that several analyses of the sewage and effluent made in 1899 showed a satisfactory degree of purification up to the end of the year. He also said: "The Leicester sewage is quite strong, and one of the most interesting features of these works to me is the good results obtained with an apparently unpromising material."


COX'S STADIA COMPUTER.
DIFFERENCE OF ELEVATION
HOR. DISTANCE
Directions for Use.
Set the arrow, marked zero on the disc, opposite the reading of the rod on the outer scale.
Opposite the vertical angle of the transit telescope find the Difference of Elevation, and opposite the same angle on the Distance Scale find the Horizontal Distance.
EXAMPLE:
Vertical angle 12° 30', reading of the Rod 537 feet. Set the zero of the disc opposite 537, and opposite 12° 30' of the scale at the left read 119½ feet Difference of Elevation, and opposite 12° 30', of the scale at the right read 519 feet Distance.
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ENG. NEWS.
Designed by Wm. Cox.

CIRCULAR SLIDE RULE FOR STADIA COMPUTATIONS IN THE FIELD.

A STADIA SLIDE-RULE.

The solving of stadia problems by the use of the slide-rule is not new; but the device here illustrated is intended to remove the uncertainty of movement and liability to error in observation inherent in other forms. It is designed by Mr. William Cox, of Elizabeth, N. J., and the arrangement is based upon the two well-known formulas:

Horizontal distance = 100 R × $\cos^2$ x.

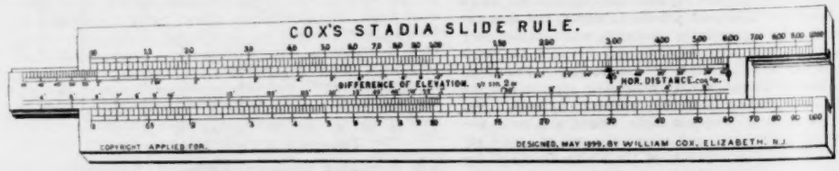
Difference in elevation = 100 R × ½ sin 2 x.

Some of the chief features of this particular slide-rule may be noted as follows: (1) The slide is always pushed to the left, so as to bring the right index of the slide to the rod-reading on the upper scale of the rule. (2) The horizontal distances and the difference of elevation are now both found opposite the angle of elevation of the transit telescope; this angle being taken, in the first case, on the right hand scale of the slide, and in the latter case, either on the left hand scale, or on the lower scale of the slide.

The setting of the angle is the only movement; there is no pushing of the scale to the right, as is the case with some other rules, and no multiplying or dividing to obtain correct results. With it the liability to error is greatly reduced.

It will be noticed that the graduations on the left half of the top scales of the rule and the slide are reproduced at the bottom and right of the slide and the rule. As a result of this arrangement, when an angle on the slide to the left is found to be beyond the rule—as, for example, the angle 50', as shown in the figure, this same angle is found on the lower scale of the slide, with the corresponding difference of elevation on the lower scale of the rule. By this simple device a single setting of the slide is sufficient for all cases, no matter how small the angle, or how far the slide is pushed to the left.

Mr. Cox has also designed a stadia-computor, here illustrated, which solves the same problems and is more convenient for field use than the slide-rule. This computor is about 6 ins. square, and is neatly mounted in a cloth cover; it is similar in its operation to the slide-rule described, and is equally simple in use. The computor has been purchased by W. & L. E. Gurley, the well-known manufacturers of engineering instruments, of Troy, N. Y., and is, we believe, distributed among purchasers and users of their instruments. The slide-rule is not yet on the market, and for the right to use it application must be made to Mr. Cox.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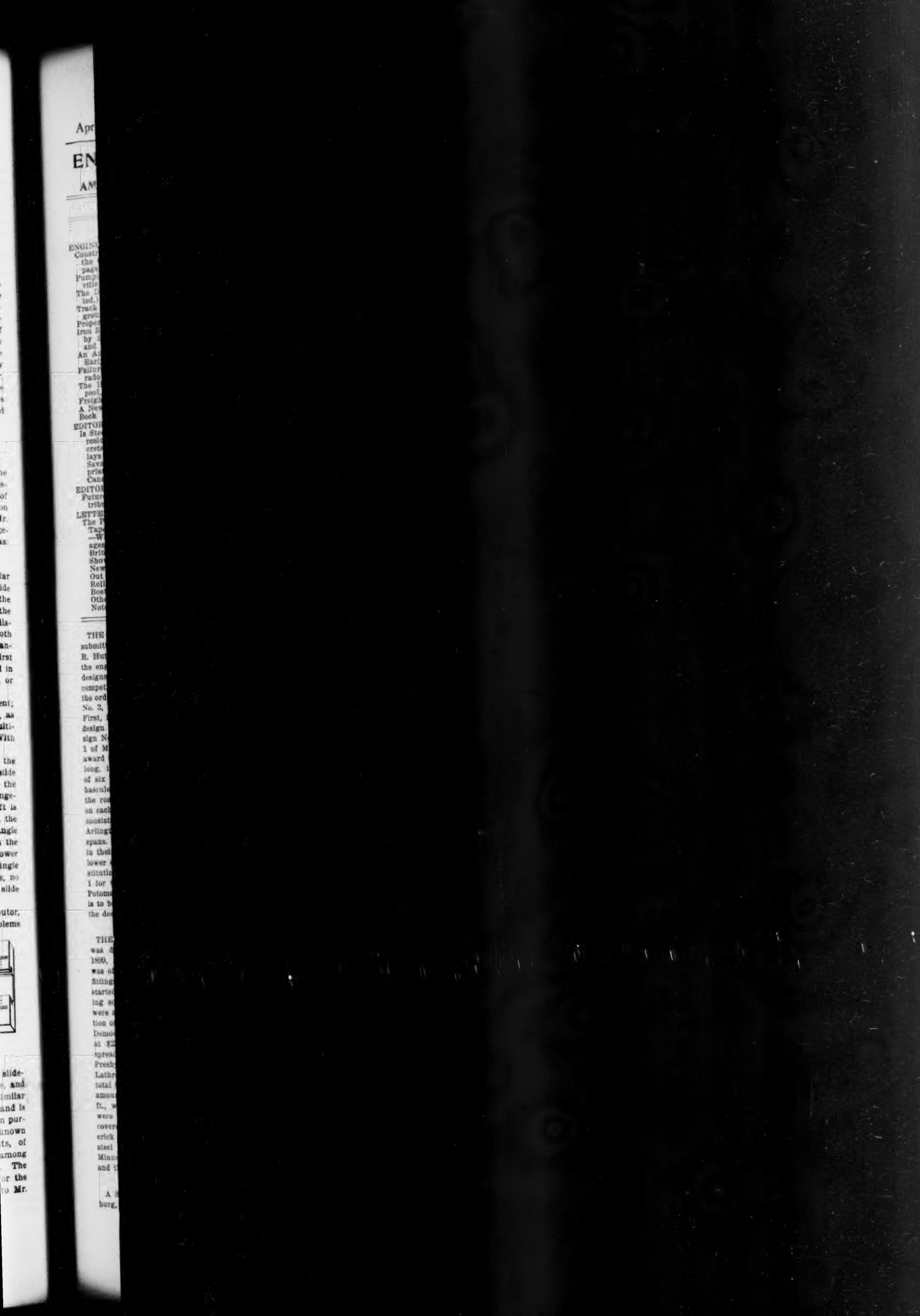
SLIDE RULE FOR STADIA COMPUTATIONS IN THE OFFICE.